

Sandia National Laboratories/New Mexico

**PROPOSALS FOR NO FURTHER ACTION
ENVIRONMENTAL RESTORATION PROJECT
AOC TNT SITE, SWMU 94H, and SWMU 190**

September 2002

Environmental
Restoration
Project



United States Department of Energy
Office of Kirtland Site Operations

EXECUTIVE SUMMARY

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a risk-based no further action (NFA) decision for the Environmental Restoration area of concern (AOC) the TNT (the acronym for 2,4,6-trinitrotoluene) Site as well as Solid Waste Management Units (SWMUs) 94H and 190. Review and analysis of all relevant data for these sites indicate that concentration levels of constituents of concern (COCs) are less than the applicable risk assessment action levels. Thus, this AOC and these SWMUs are proposed for an NFA decision based upon confirmatory sampling data demonstrating that COCs that could have been released from these sites into the environment pose an acceptable level of risk under current and projected future land use, as set forth by Criterion 5, which states, "the SWMU/AOC has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use" (NMED March 1998). This NFA proposal describes the results of characterization activities, investigations, and risk screening assessments performed at each of these three sites, which are briefly summarized here.

The TNT Site in Operable Unit (OU) 1335 is an inactive explosives site that was characterized during a SWMU assessment. The TNT Site was discovered in November 1999 when earthmoving activities uncovered unexploded TNT in the area. Kirtland Air Force Base Explosive Ordnance Disposal personnel assisted in the disposal of the unexploded TNT and the subsequent investigation of the area. Soil samples collected from the area indicated the presence of a few high explosives-related compounds at concentrations not considered to be hazardous to human health for an industrial land use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with the TNT Site were very low and that this site meets the criterion for NFA.

SWMU 94H, the JP-8 (jet propulsion fuel grade 8) Fuel Spill Site in OU 1333, is a recent subunit, discovered in August 2000 during the excavation of a trench near the north side of the Small Open Burn Pit and directly west of the Large Open Burn Pit. SWMU 94H was characterized and remediated during a Voluntary Corrective Action (VCA) conducted in 2001, which included confirmatory sampling. The only COCs remaining after the VCA were a few metals detected at levels above background concentration limits, none of which were present at concentrations considered to be hazardous to human health under a recreational land use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 94H were very low. Therefore, this site is proposed for an NFA decision.

SWMU 190, the Steam Plant Tank Farm in OU 1302, is an active tank farm with five aboveground storage tanks located in the southwest portion of Technical Area I. Environmental concern for SWMU 190 is based upon soil contaminated with #2 diesel fuel oil resulting from a documented release in June 1991 when workers discovered fuel oil upwelling to the land surface. SWMU 190 was characterized during seven field investigations, including the discovery of the release with associated excavation and sampling in June 1991; a passive soil-gas survey completed in April and May 1994; a near-surface Geoprobe™ investigation completed in May 1995; a laser-induced fluorescence/cone penetrometer study completed in November 1995; a deep-borehole investigation completed in November 1996; a deep-borehole investigation associated with the installation of the Expedited Cleanup/Voluntary Corrective

Measure system at the site of the known pipeline rupture in November 1998; and groundwater investigations from both on-site and nearby groundwater monitoring wells. The COCs at SWMU 190 included total petroleum hydrocarbons and associated volatile and semivolatile organic compounds, none of which were present at concentrations considered to be hazardous to human health or the environment under an industrial land use scenario. Based upon the results of both the risk screening assessment and the investigations performed at SWMU 190, this site is proposed for an NFA decision.

REFERENCES

New Mexico Environment Department (NMED), March 1998. "Risk-Based Decision Tree Description," in New Mexico Environment Department, "RPMP Document Requirement Guide," RCRA Permits Management Program, Hazardous and Radioactive Materials Bureau, New Mexico Environment Department, Santa Fe, New Mexico.

NMED, see New Mexico Environment Department.

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1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a no further action (NFA) recommendation for three Environmental Restoration Solid Waste Management Units (SWMUs). The following SWMUs are listed in the Hazardous and Solid Waste Amendments Module IV of the SNL/NM Resource Conservation and Recovery Act Hazardous Waste Management Facility Permit (NM5890110518) (EPA August 1993). Proposals for each SWMU are located in this document as follows:

- The TNT Site, Southwest Test Area (Chapter 2.0)
- SWMU 94H, JP-8 Site, Lurance Canyon Burn Site (Chapter 3.0)
- SWMU 190, Steam Plant Tank Farm, Technical Area I (Chapter 4.0)

Each proposal provides a site description and history, summary of investigatory activities, and the rationale for the NFA decision, as determined from assessments predicting acceptable levels of risk under current and projected future land use.

REFERENCES

EPA, see U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency (EPA), August 1993. "Module IV of RCRA Permit No. NM5890110518-1," EPA Region VI, issued to Sandia National Laboratories, Albuquerque, New Mexico.

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- 4-A Well Completion Diagrams
- 4-B Risk Screening Assessment
- 4-C Surface-Water Site Assessment

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CHAPTER 4.0 ACRONYMS AND ABBREVIATIONS

AOC	area of concern
ATI	Analytical Technologies, Inc.
bgs	below ground surface
COC	constituent of concern
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQO	data quality objective
EC/VCM	Expedited Cleanup/Voluntary Corrective Measure
Eh	oxidation/reduction potential
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
FOP	Field Operating Procedure
GEL	General Engineering Laboratory
HI	hazard index
KAFB	Kirtland Air Force Base
kg	kilogram(s)
L	liter(s)
LIF/CPT	laser-induced fluorescence/cone-penetrometer test
MDL	method detection limit
µg	microgram(s)
mg	milligram(s)
NFA	no further action
NMED	New Mexico Environment Department
RFI	Resource Conservation and Recovery Act Facility Investigation
ROST	Rapid Optical Screening Tool
SCAPS	Site Characterization and Analysis Penetrometer System
SNL/NM	Sandia National Laboratories/New Mexico
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TA	Technical Area
TAG	Tijeras Arroyo Groundwater
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons
VOC	volatile organic compound
Weston	Roy F. Weston, Inc.

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4.0 SOLID WASTE MANAGEMENT UNIT 190, THE STEAM PLANT TANK FARM

4.1 Summary

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a risk-based no further action (NFA) decision for Environmental Restoration (ER) Solid Waste Management Unit (SWMU) 190, the Steam Plant Tank Farm, Operable Unit 1302, on Kirtland Air Force Base (KAFB). SWMU 190 is located on federally-owned land controlled by KAFB (Figure 4.1-1). Environmental concern for SWMU 190 is based upon soil contaminated with No. 2 diesel fuel oil (hereafter referred to as "fuel oil").

A release of fuel oil was documented at the site in June 1991 (SNL/NM February 1995). Workers discovered fuel oil upwelling to the land surface in an area northwest of Tank 5 and northeast of Tank 4. This area was excavated, and a leaking pipe was discovered approximately 2.5 feet below ground surface (bgs). The pipe was cut and capped at both ends to prevent further leakage. Facilities personnel continued excavating soil during the following weeks to a depth of approximately 15 feet and a horizontal extent of 50 by 32 feet. However, the full extent of the contamination could not be determined, and the excavated pit was backfilled with the original contaminated soil. On August 27, 1991, the Steam Plant Tank Farm was listed as ER Site 190, which is now referred to as "SWMU 190" (Gaither August 1991a, SNL/NM February 1995).

Review and analysis of all relevant data for SWMU 190 indicate that concentration levels of constituents of concern (COCs) are below applicable risk assessment action levels. Thus, SWMU 190 is being proposed for an NFA decision based upon soil sampling data. This NFA demonstrates that residual contamination associated with SWMU 190 poses an acceptable level of risk under current and projected future land use (DOE and USAF September 1995) as set forth by NFA Criterion 5, which states, "the SWMU/AOC [area of concern] has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicated that contaminants pose an acceptable level of risk under current and projected future land use" (NMED March 1998).

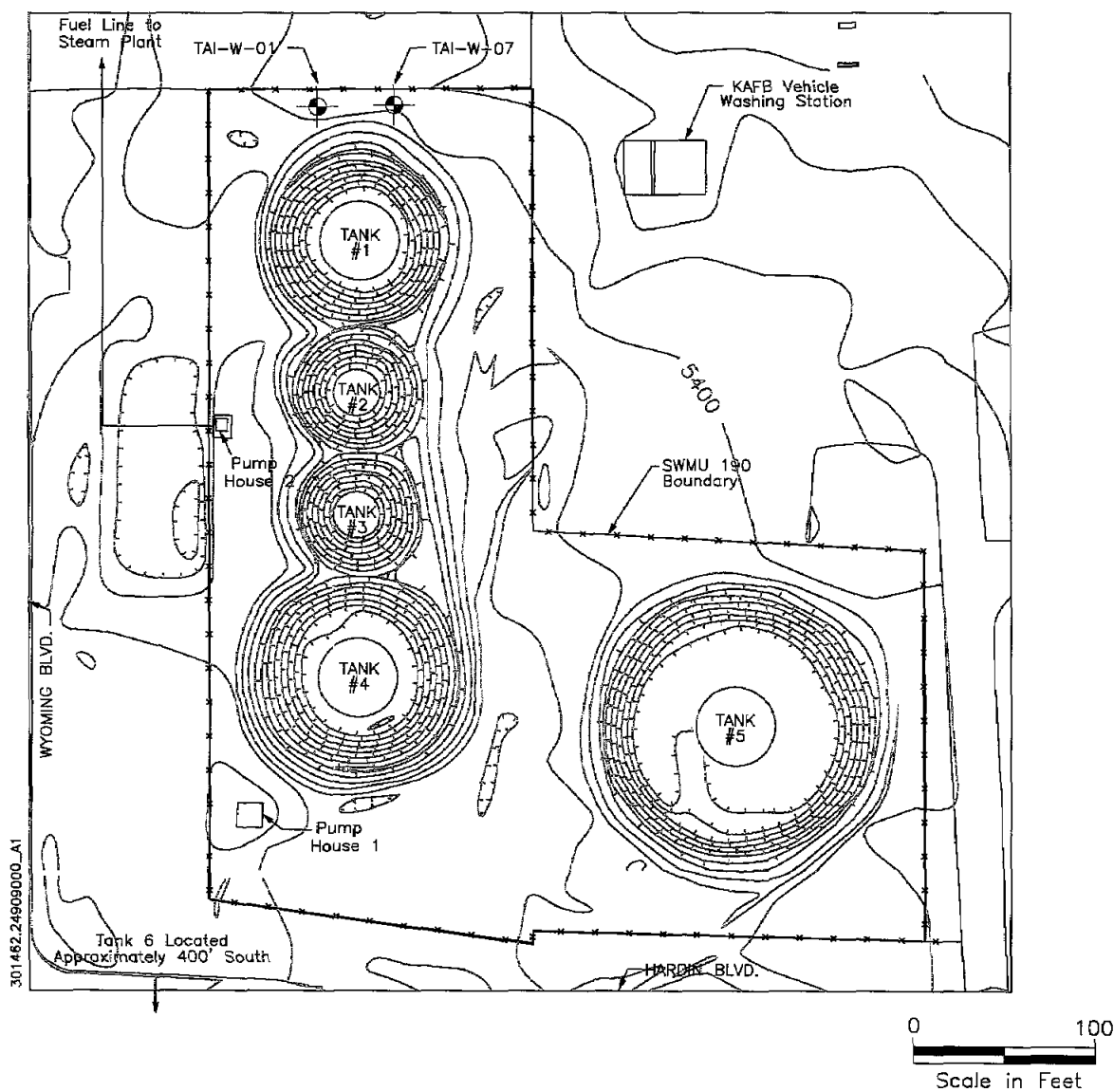
4.2 Description and Operational History

Section 4.2 describes the SWMU 190 site and discusses its operational history.


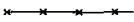

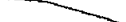
4.2.1 Site Description

SWMU 190 is an active tank farm located in the southwest portion of Technical Area (TA)-I at the northeast corner of Hardin and Wyoming Boulevards (Figure 4.1-1). The site comprises approximately three acres, is completely fenced, and contains five large, aboveground storage tanks (Figure 4.2.1-1). A sixth aboveground storage tank, located south of the site boundary on the south side of Hardin Boulevard, is not considered part of the site.

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Legend

-  Structures
-  Fence Line
-  Groundwater Monitoring Well
-  1-foot Elevation Contours

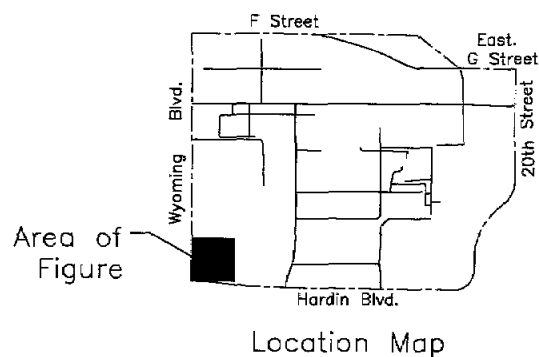
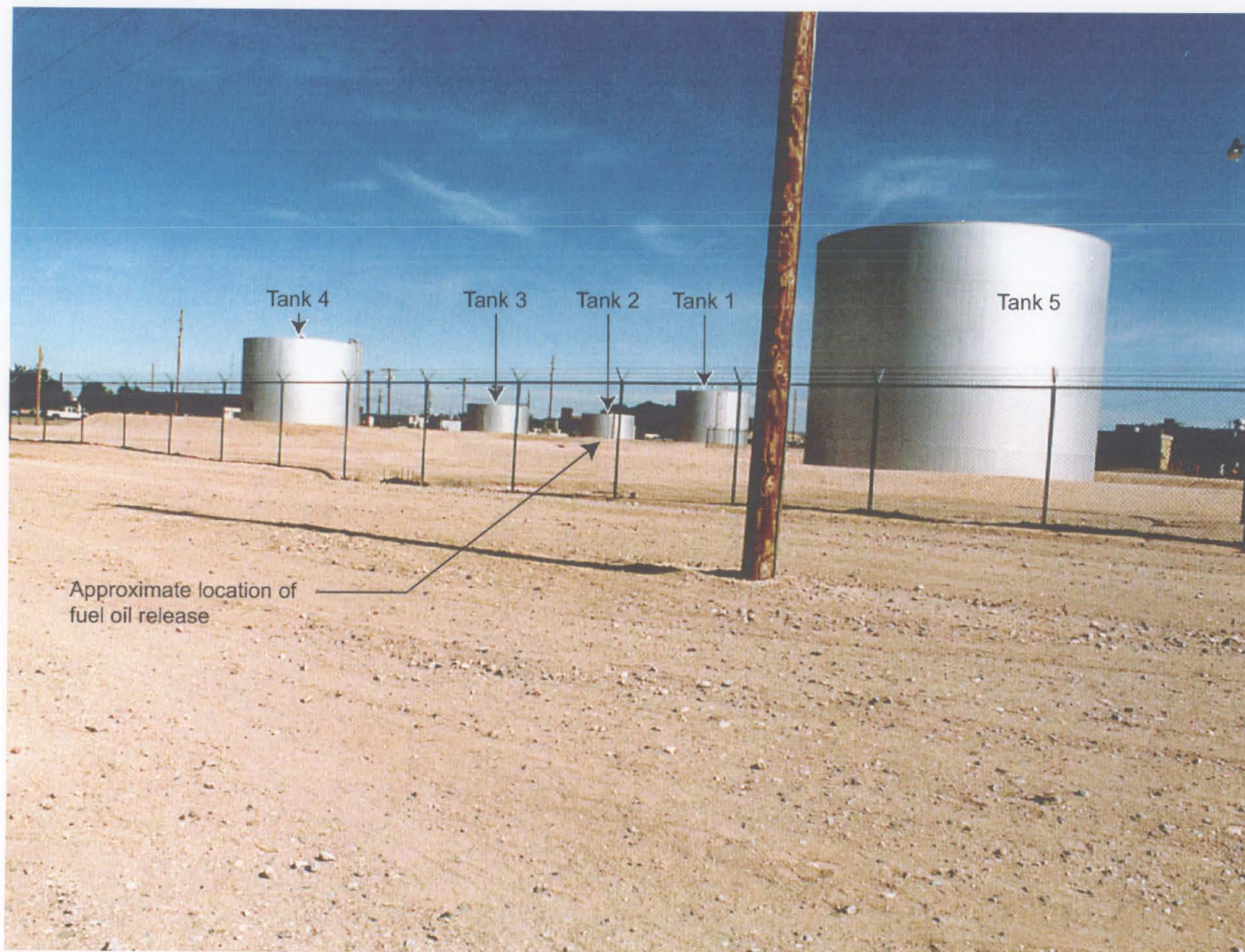


Figure 4.1-1
SWMU 190, Steam Plant Tank Farm



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Figure 4.2.1-1
Steam Plant Tank Farm, June 1993
(view is to the northwest from approximately Hardin Boulevard)

On a regional scale, SNL/NM is located near the east-central edge of the Albuquerque Basin. The Albuquerque Basin is a rifted graben within the larger Rio Grande Rift System, bounded on the east and west by predominantly north-south trending faults. The site is located west of the Sandia Fault (or Fault Zone), which is a down-to-the-west basin bounding fault of the Albuquerque Basin (Hawley and Haase 1992). The site's topography, climate, soil, hydrology, geology, ecology, cultural resources, and demographics are detailed in the TA-I Resource Conservation and Recovery Act Facilities Investigation (RFI) Work Plan (SNL/NM February 1995).

The site rests on a partially dissected bajada formed by coalescing alluvial fan complexes that originate in the mountain ranges to the east. The Holocene and Pleistocene deposits on the surface are comprised of alluvial fan deposits shed from the eastern uplifts that interfinger with valley alluvium. The thickness of these Holocene and Pleistocene deposits is thought to be less than 10 feet (SNL/NM March 1994). Surficial deposits derived from the Tijeras Arroyo drainage contain granitic and sedimentary lithologies from the Sandia Mountains, as well as sedimentary and metamorphic lithologies from the Manzanita Mountains.

The soil at the site has been identified as part of the Embudo-Tijeras Complex, which consists of deep, well-drained, moderately alkaline soil (pH of 7.9 to 8.4) that formed in decomposed granitic alluvium on old alluvial fans (Hacker 1977). Permeability of this soil is moderate (0.6 to 2.0 inches/hour). The term "soil" in this context refers to the weathered and biologically altered horizons above and within unconsolidated deposits, as soil scientists define it. Throughout the remainder of this NFA Proposal, the term "soil" refers to any unconsolidated deposits whether or not the deposits contain developed soil horizons, as defined by engineers, who have devised a soil classification based upon mixtures of clay, silt, sand, and gravel to describe unconsolidated deposits.

Groundwater monitoring for the area surrounding SWMU 190 is conducted as part of the Tijeras Arroyo (formerly Sandia North) Groundwater (TAG) Investigation (SNL/NM March 1996). Two water-bearing zones, the shallow groundwater system and the regional aquifer, underlie SWMU 190. Two monitoring wells (TAI-W-01 and TAI-W-07, regional aquifer and shallow groundwater system wells, respectively) are located immediately north of Tank 1 within the boundaries of SWMU 190 (Figure 4.1-1). The depth to the shallow groundwater system is approximately 275 feet bgs and approximately 535 feet to the regional aquifer. The shallow groundwater system flows in a southeasterly direction and is not used for water supply purposes. Both the City of Albuquerque and KAFB use the regional aquifer as a water supply source. The nearest regional aquifer water-supply well is KAFB-1, located approximately one-half mile northwest (downgradient) of the site. Pumping of city wells has created a cone of depression in the northern portion of SNL/NM that affects groundwater flow in the regional aquifer in the vicinity of the site.

The natural ground surface at the site is nearly level, with a gradual slope to the south of 1 to 2 percent. Man-made secondary containment berms with local relief of 5 to 8 feet were constructed around each of the five aboveground storage tanks within SWMU 190. Elevations from north to south across the main portion of the site vary from 5,401 to 5,396 feet above mean sea level, for a total natural relief across the site of 5 feet. A surface-water channel cuts across the site from northeast to the southwest and becomes part of the TA-I storm-water system just outside the southwest corner of the site.

A major drainage feature in the vicinity of the site is the Tijeras Arroyo, which is located approximately 0.75 miles southeast of the site. Surface runoff from the site and surrounding

areas of TA-I is collected in a combined aboveground and underground storm-drain system that discharges adjacent to TA-IV into the Tijeras Arroyo. The arroyo originates in Tijeras Canyon, which is bounded by the Sandia Mountains to the north and the Manzanita/Manzano Mountains to the south. The arroyo trends southwest to west, eventually draining into the Rio Grande, approximately 8 miles west of SWMU 190.

The site has been heavily disturbed by human activity for more than 50 years. Generally, the diversity and abundance of ecological species in areas within and around TA-I varies at given locations depending upon the quantity and quality of available habitat. Because of the amount of human intrusion at the site, a diverse ecosystem is unlikely, although the site-specific species have not been quantified. As part of fire-hazard mitigation, vegetation is completely controlled by either herbicides or removal; therefore, no suitable habitat remains within the site boundaries to sustain a viable ecological system.

4.2.2 Operational History

The aboveground storage tanks are built on concrete pads that are surrounded by native soil, with berms of native material providing secondary containment. All five aboveground storage tanks previously contained fuel oil to be used as a backup supply system for the SNL/NM Steam Plant when the primary fuel supply (natural gas) was unavailable. Currently, Tanks 1 through 4 are empty except for residual product; Tank 5 is still operational. If necessary, Tank 5 would supply backup fuel oil via underground piping through Pump House 1 to the Steam Plant, located 1,700 feet to the north.

The original Steam Plant Tank Farm, consisting of Tanks 2, 3, and 4; Pump House 2; and associated pipelines, was constructed in the late 1940s (Weston July 1994) and released to SNL/NM by KAFB in 1950 (Gaither August 1991a). Tank 1 was constructed between 1964 and 1967; and Tanks 5, 6, and Pump House 1 were constructed between 1967 and 1973 (Weston July 1994). The backup supply system has never been utilized, and Tank 5 contains the original product delivered. On-site capacities are as follows:

Tank	Capacity (gallons)
1	250,000
2	50,000
3	50,000
4	250,000
5	500,000

Two pump houses (Figure 4.1-1) service the Steam Plant Tank Farm. Pump House 1 is located south of Tank 4 and services Tanks 5 and 6, as well as the truck off-loading station. Pump House 2 is located southwest of Tank 2 and services Tanks 1 through 4.

In June 1991, the only known release of fuel oil occurred at this location. The known release and associated events caused the Steam Plant Tank Farm to be listed as a SWMU. The first in the series of events to have impacted the site occurred outside of SWMU 190 at SWMU 32 (SNL/NM July 1995). On or around June 4, 1991, the main valve of Tank 5 was inadvertently left open during a fuel-oil sampling event that caused more than 5,000 gallons (exact volume unknown) of fuel oil to slowly drain through the pipeline and into Underground Storage Tank 605-8 (SWMU 32), located at the Steam Plant. This and other underground storage tanks

at the Steam Plant were supposed to have been empty. On June 25, maintenance workers noticed the concrete vault above Tank 605-8 was filled and overflowing with fuel oil (SNL/NM July 1995, Gaither August 1991a).

SNL/NM facilities personnel called a tanker truck company to remove the fuel oil from the underground storage tank and haul it to Tank 5. After one 5,000-gallon load was transferred to Tank 5, workers discovered fuel oil upwelling to the land surface at an area outside the berm northeast of Tank 4 and northwest of Tank 5. The remaining fuel oil in Tank 605-8 at the Steam Plant was removed and transported off site by the tanker trucking company.

A few days later (thought to be June 28—exact date unknown), the area northeast of Tank 4 and northwest of Tank 5 was excavated and a leaking pipe was discovered, which was then cut and capped. After a few weeks (sometime in early August), facilities personnel continued excavating the soil in an attempt to determine the full extent of fuel-oil contamination. The maximum dimensions of the excavation pit reached 50 by 35 by 15 feet (Figure 4.2.2-1).

During excavation, it became evident that the fuel-oil release was much greater than anticipated (Gaither August 1991a). Although the full horizontal and vertical extent of contamination had not been determined, the excavation was discontinued and the pit backfilled with the original fuel-oil contaminated soil (Cox August 1991). On August 27, 1991, the Steam Plant Tank Farm was listed as SWMU 190 (Gaither August 1991a).

During the preparation of the RFI Work Plan, "future plans" tentatively proposed the removal of the four original aboveground storage tanks (Tanks 1 through 4) and associated piping (SNL/NM February 1995). Because of the capacities of Tanks 5 and 6, Tanks 1 to 4 are no longer needed. However, as of 2002 (and into the foreseeable future), no funding has been allocated for the removal of these tanks (Langkopf April 2002). If future funding were to become available, the decontamination and demolition activities at SWMU 190 may include removing the aboveground storage tanks and associated piping.

4.3 Land Use

This section discusses the current and projected future land uses of SWMU 190.

4.3.1 Current Land Use

SWMU 190 is presently an active site located within the boundaries of KAFB. The current land use is industrial.

4.3.2 Future/Proposed Land Use

SWMU 190 has been recommended for industrial land use in the future (DOE and USAF September 1995). The Steam Plant Tank Farm will be maintained as the backup fuel source for the Steam Plant.

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Figure 4.2.2-1
Excavation at SWMU 190 During Investigation #1, August 1991
(view is to the east; Tank 5 is in the background [Gaither 1991b])

4.4 Investigatory Activities

SWMU 190 has been characterized in multiple investigations and partially remediated during an Expedited Cleanup/Voluntary Corrective Measure (EC/VCM). This section discusses the SWMU 190 investigatory and remediation activities.

4.4.1 Summary

SWMU 190 soil contamination has been examined in a series of six investigations since the early 1990s. Highlights of the investigations, operational history, and regulatory interactions are provided in Table 4.4.1-1, with cross-references to sections of the text that discuss the details of the investigations and provide reference citations.

The field investigations of soil contaminated by fuel oil at SWMU 190 consisted of:

- Investigation #1—the discovery of the release at the known pipeline rupture, with associated excavation and sampling completed in June 1991;
- Investigation #2—a passive soil-gas survey completed during April and May 1994;
- Investigation #3—a near-surface Geoprobe™ investigation completed in May 1995;
- Investigation #4—a laser-induced fluorescence/cone-penetrometer test (LIF/CPT) study completed in November 1995;
- Investigation #5—a deep-borehole investigation completed in November 1996; and
- Investigation #6—a deep-borehole investigation associated with the installation of the EC/VCM system at the known pipeline rupture completed in November 1998.

Investigations #3 and #5 were carried out under an RFI Work Plan (SNL/NM February 1995) to determine the nature and extent of hazardous constituents in soil. Investigation #4 was conducted under another subcontractor's work plan (PRC August 1995) associated with verification of an innovative investigation technique. Although not technically part of the RFI, the LIF/CPT results were presented along with RFI results in two separate Data Evaluation Reports (SNL/NM June 1996, SNL/NM January 1997).

Based upon the results of Investigations #1 through #5, Investigation #6 was conducted in 1998 and included additional site characterization as well as installation of a bioventing remediation system (Weston October 1998). Although all of the soil samples collected at the site during the earlier investigations showed that COC concentrations were at an acceptable risk level (discussed in Section 4.6), the EC/VCM was implemented in accordance with the ER Project's philosophy concerning "Best Management Practices." No verification samples have been collected to determine the effectiveness of the bioventing system. This NFA Proposal describes only briefly the installation of the bioventing system (Weston October 1998) and presents the

Table 4.4.1-1
Historical Timeline for SWMU 190

Month	Year	Event	Discussed in Section	Reference
	Late 1940's (pre-1951)	Tanks 2, 3, and 4, and Pump House 2 installed.	4.2.2	Gaither August 1991a Weston July 1994
	Between 1964 and 1967	Tank 1 installed.	4.2.2	Weston July 1994
	Between 1967 and 1973	Tanks 5 and 6, and Pump House 1 installed.	4.2.2	Gaither August 1991a Weston July 1994
June	1991	Site workers discover leaking pipe in the Tank Farm; pipe cut and capped.	4.2.2 and 4.4.2	Gaither August 1991a
July	1991	Sample of contaminated soils collected and sent for analyses.	4.4.2	IT August 1991
August	1991	Excavation ceased after reaching depth of 15 ft. Extent of contamination could not be determined. Contaminated soils returned to the excavation.	4.4.2	Gaither August 1991a,b,c Cox August 1991
August	1991	Steam Plant Tank Farm listed as "ER Site 190" (now referred to as SWMU 190).	4.2.2	Gaither August 1991a
April/ May	1994	PETREX passive soil-gas survey completed.	4.4.3	IT July 1994 NERI June 1994
February	1995	Final Draft of the Technical Area-I RFI Work Plan produced.	--	SNL/NM February 1995
May	1995	Surface and near-surface Geoprobe™ sampling (Phase 1 RFI) completed; samples collected between 0 and 30 ft at 40 locations.	4.4.4	SNL/NM June 1996
November	1995	LIF/CPT Demonstration Project completed.	4.4.5	PRC September 1995 PRC December 1995
November	1996	Deep borehole sampling (Phase 2 RFI) completed; samples collected to a maximum depth of 111 ft at 8 locations.	4.4.6	SNL/NM January 1997
February	1997	RFI sampling analytical results for surface and near-surface Geoprobe™ sampling documented in the Data Evaluation Report.	4.4.4	SNL/NM June 1996
July	1997	RFI supplemental sampling analytical results for the deep borehole sampling documented in a Supplemental Data Evaluation Report.	4.4.6	SNL/NM January 1997
August	1998	EC/VCM plan discussed at a public meeting.	--	--
October	1998	EC/VCM plan finalized.	4.4.7	Weston October 1998
November	1998	EC/VCM bioventing system installed at the known pipeline rupture.	4.4.7	Weston July 1999

EC/VCM = Expedited Cleanup/Voluntary Corrective Measure.
 ER = Environmental Restoration.
 ft = Foot (feet).
 IT = IT Corporation.
 LIF/CPT = Laser-induced fluorescence/cone penetrometer test.
 NERI = Northeast Research Institute, LLC.
 PRC = PRC Environmental Management, Inc.
 RCRA = Resource Conservation and Recovery Act.
 RFI = RCRA Facility Investigation.
 SNL/NM = Sandia National Laboratories/New Mexico.
 SWMU = Solid Waste Management Unit.
 Weston = Roy F. Weston, Inc.
 -- = Information either not discussed in this report or did not have an associated reference.

analytical data from borehole soil samples collected during the installation of the system. The EC/VCM bioventing system continues to operate, removing COCs from the soil in the area of the known pipeline rupture.

An additional study (Investigation #7) consists of a compilation of analytical data from nearby groundwater monitoring wells. Although the groundwater monitoring wells discussed in Investigation #7 were not installed specifically to address SWMU 190 fuel-oil contamination, the data provide further delineation of the extent of contamination from the known pipeline rupture.

Summaries of the field investigations are presented in chronological order starting with the discovery of the release. During the RFI, sample numbers were coded to identify specific information. For example, "TI190-GP001-005" refers to the TA and SWMU number (TA-I, SWMU 190), the Geoprobe™ location number, and the end depth of the borehole (in feet). Some of the soil sample analytical results were originally reported in parts per million and parts per billion, whereas others are reported in milligrams (mg) per kilogram (kg) and micrograms (µg)/kg. Regardless of the soil concentration units originally reported, this NFA Proposal uses the concentration descriptor of µg/kg for total petroleum hydrocarbons (TPH), semivolatile organic compounds (SVOCs), and volatile organic compounds (VOCs).

4.4.2 Investigation #1—Discovery of the Fuel-Oil Release

Investigation #1 was the discovery of the release at the known pipeline rupture, followed by excavation to determine the extent of fuel-oil contamination and soil sample collection to determine TPH concentrations and waste characteristics.

4.4.2.1 *Nonsampling Data Collection*

Nonsampling data collection activities conducted as part of Investigation #1 were limited to using heavy equipment to determine the extent of visibly contaminated soils.

4.4.2.2 *Sampling Data Collection*

On July 15, 1991 grab sample SNLA005404 was collected from the fuel-oil release site at SWMU 190. The sample consisted of soil from a depth of approximately 5 feet bgs removed from the vicinity of the known pipeline rupture (Figure 4.2.2-1). Based upon field judgment of visible contamination, this sample was thought to represent maximum contamination levels. The sample was collected to determine TPH levels in the soil for waste management characterization and was analyzed for TPH (Analytical Method 3550/418.1), polychlorinated biphenyls (Method 8080), and toxicity characteristic leaching procedure metals (Methods 6010, 7470, and 7740) (EPA November 1986).

4.4.2.3 *Data Gaps*

The sampling team did not survey exact sample locations. The vertical and horizontal extent of contamination was not determined.

4.4.2.4 *Results and Conclusions*

All analytes were nondetect except for TPH (17,200 mg/kg) and barium (1.6 mg per liter [L]) (IT August 1991). During excavation, it became evident that the fuel-oil release was much greater than anticipated (Gaither August 1991a). Although the full horizontal and vertical extent of contamination had not been determined, the excavation was discontinued and the pit backfilled with the original fuel-oil contaminated soil (Cox August 1991).

4.4.3 *Investigation #2—PETREX Passive Soil-Gas Survey*

Investigation #2 consisted of a limited passive soil-gas survey conducted in April 1994. This survey was conducted at the site because excess soil-gas samplers (PETREX samplers) and associated funding for analysis were available from another SWMU investigation at SNL/NM. It was anticipated that the results of this "no-cost" survey could help determine the nature and extent of contamination at the site.

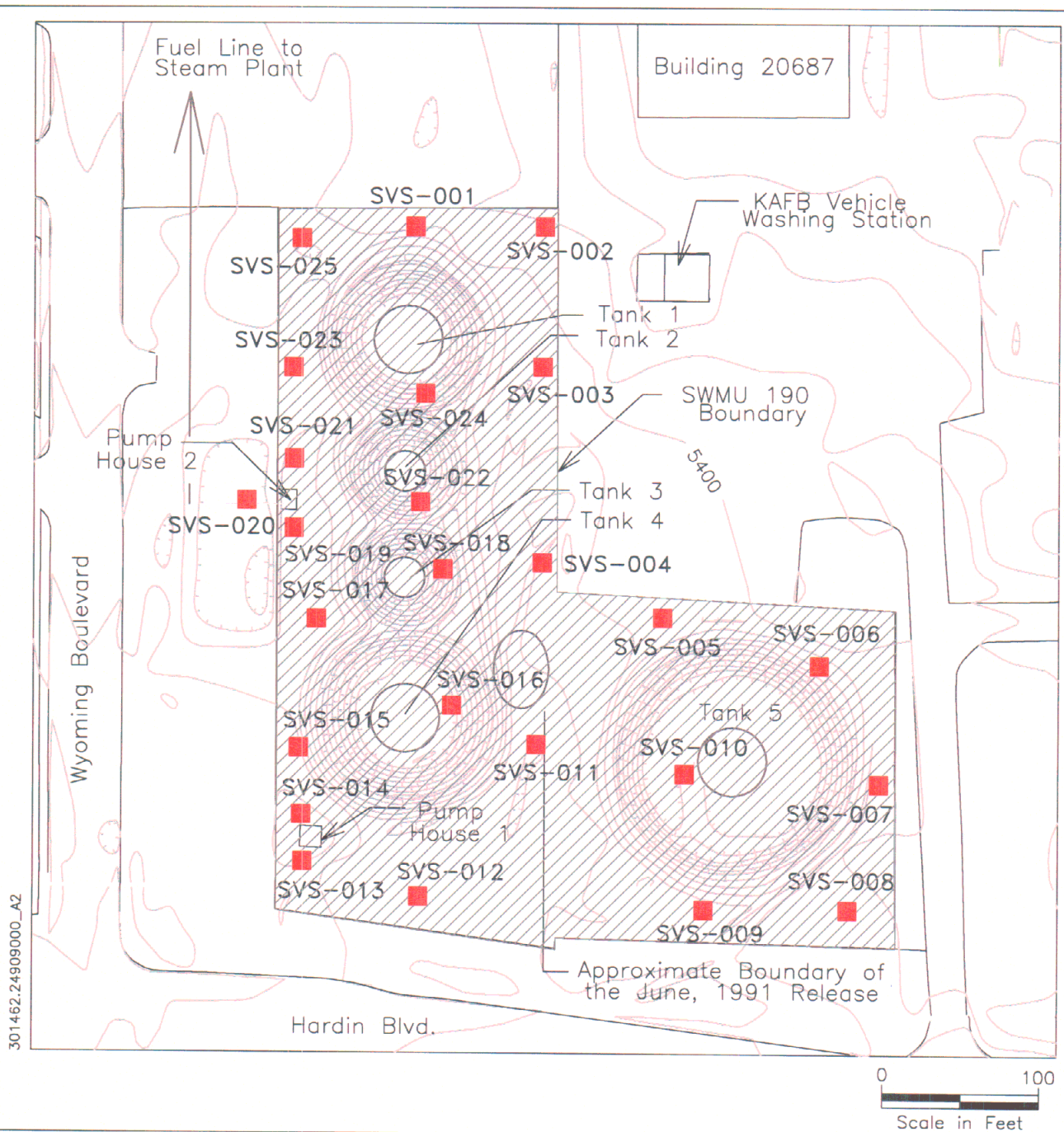
The PETREX soil-gas collectors consist of activated charcoal adsorption elements in an inert atmosphere contained by a resealable glass tube. The opened collectors were installed 18 inches bgs and exposed for approximately three weeks. The sampler exposure time was determined to be two to three weeks according to exposure-time test samplers (time tests) at other SNL/NM locations (NERI June 1994). The response values (analytical results) are reported as ion counts. Ion counts are the unit of measure assigned by the mass spectrometer to the relative intensities associated with each of the reported compounds. These ion counts do not correlate to actual concentrations of reported compounds. Therefore, the values are best used as a semi-quantitative measure for which a change in ion counts of an order of magnitude is considered significant for distinguishing potential hot spots from background areas (NERI June 1994).

4.4.3.1 *Nonsampling Data Collection*

There were no nonsampling data collection activities associated with Investigation #2 of SWMU 190.

4.4.3.2 *Sampling Data Collection*

Twenty-five collectors were installed at locations around the aboveground storage tanks, along pipelines, at the site perimeter, and adjacent to the pump houses (Figure 4.4.3-1). IT Corporation installed the collectors on April 27, 1994, using a bucket-style hand auger. After the collectors were placed, the holes were backfilled with native soils, flagged, and the locations measured from the corner of Pump House 2 (IT July 1994). The collectors were removed on May 20, 1994, and sent to Northeast Research Institute's analytical laboratory in Lakewood, Colorado, to be analyzed for VOCs and SVOCs by thermal desorption—mass spectrometry or thermal desorption—gas chromatography/mass spectrometry.



Legend



Structures



5425

5-ft Contours



1-ft Contours



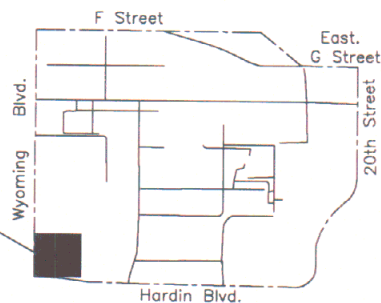
SWMU 190



SVS-013

PETREX Passive Soil-Gas Sample Locations

Area of Figure



Location Map

Figure 4.4.3-1
PETREX Passive Soil-Gas Sampling Locations
Investigation #2

4.4.3.3 *Data Gaps*

No quantitative evaluation of contamination could be obtained from the passive soil-vapor survey.

4.4.3.4 *Results and Conclusions*

The analytical results for these 25 samples found values near background ion counts for Samples -001 through -006, -008, -009, -011 through -017, and -021 through -025. Samples -007, -010, -018, -019, and -020 showed elevated (one order of magnitude) ion count values for benzene, toluene, ethylbenzene/xylenes, and C4-C15 aliphatic hydrocarbons (IT July 1994). The data suggested the presence of some hydrocarbons but no quantitative evaluation was possible. During subsequent investigations (discussed in the following sections), soil samples were collected at or near the PETREX sample locations that exhibited elevated ion counts.

4.4.4 Investigation #3—Geoprobe™ Investigation

In addition to the known pipeline rupture, one other potential release had been identified at SWMU 190 prior to the development of the RFI Work Plan. In 1989, the Tiger Team observed a potential release at Pump House 2. This pump house is approximately 10 by 6 feet and the floor is 7 feet bgs. Pump House 2 contains pumps that distribute the fuel oil to and from Pump House 1 and Tanks 1 through 4. At the time of the Tiger Team, there was a 3- to 4-inch accumulation of fuel oil from leaking pumps standing on the floor of the pump house. The floor of the pump house contains a French drain that was thought to be connected to a buried gravel retention pit (Gaither August 1991c). The potential release in the pump house was incorporated into the sampling strategy proposed in the RFI Work Plan (SNL/NM February 1995).

As specified in the RFI Work Plan (SNL/NM February 1995), the conceptual model for SWMU 190 in 1995 was as follows:

- SWMU 190 contained a known source of contamination and other potential sources of contamination.
- The only known source of contamination at the time was the documented 1991 pipeline rupture.
- Undocumented but potential sources of contamination may have included fuel-oil leaks in the piping system similar to (but probably less severe than) the known release, leaks in the pump house through the floor drain, and leaks in the aboveground storage tanks.
- The areal extent of fuel-oil contamination was not known but was considered to be across the site.
- The vertical extent of contamination was unknown (at least 15 feet deep at the June 1991 release site), but a possible extent of hundreds of feet bgs was anticipated. This assumption is based upon the potential volume involved at the June 1991 release site. The size of the release uncovered by the 1991 excavation

indicated either that the pipe leaked for a long time before being noticed or that the fuel-oil release moved through the soil more quickly than expected. Therefore, it was deemed possible that fuel oil was migrating through the vadose zone toward the water table.

The site-specific data quality objectives (DQOs) developed in 1995 for the SWMU 190 investigation included the following:

- Determining horizontal and vertical extent as well as maximum concentration of hydrocarbons in the area of the known release;
- Determining whether soil containing hydrocarbons occurred in other areas of the Steam Plant Tank Farm (such as the area around Pump House 2) at concentrations above levels detectable by immunoassay field screening (Level I); and
- Characterizing the vertical and horizontal extent of potentially contaminated soil by using Geoprobe™ soil sampling and a deep borehole investigation (Level II and III).

These DQOs were achieved by analyzing soil samples collected using the strategy described in Section 4.4.4.2. When hydrocarbons were detected in the Geoprobe™ soil samples at concentrations above the field screening method detection limit, additional samples were collected from lower depths. If the Geoprobe™ laboratory analytical samples from the lowest depth showed detectable concentrations, then the location was further investigated using a drill rig (see Investigation #5).

4.4.4.1 Nonsampling Data Collection

The nonsampling data collection activities associated with Investigation #3 included:

- Review of engineering drawings to determine pipeline locations;
- Interviews with site workers regarding the activities conducted during the discovery of the release (Gaither August 1991a); and
- Review of aerial photographs to document the development of the Tank Farm (Weston July 1994).

Results of these data collection activities were incorporated into the site conceptual model and used to determine the sampling locations and depths specified in the RFI Work Plan (SNL/NM February 1995).

4.4.4.2 Sampling Data Collection

Investigation #3 was completed in May 1995 and consisted of collecting soil samples from 40 locations throughout the site (GP001 through GP040) (Figure 4.4.4-1) using a truck-mounted Geoprobe™. The Geoprobe™ was not used at location GP036 due to limited access at the time; instead a hand auger was used to collect samples from 2 and 5 feet bgs. Geoprobe™

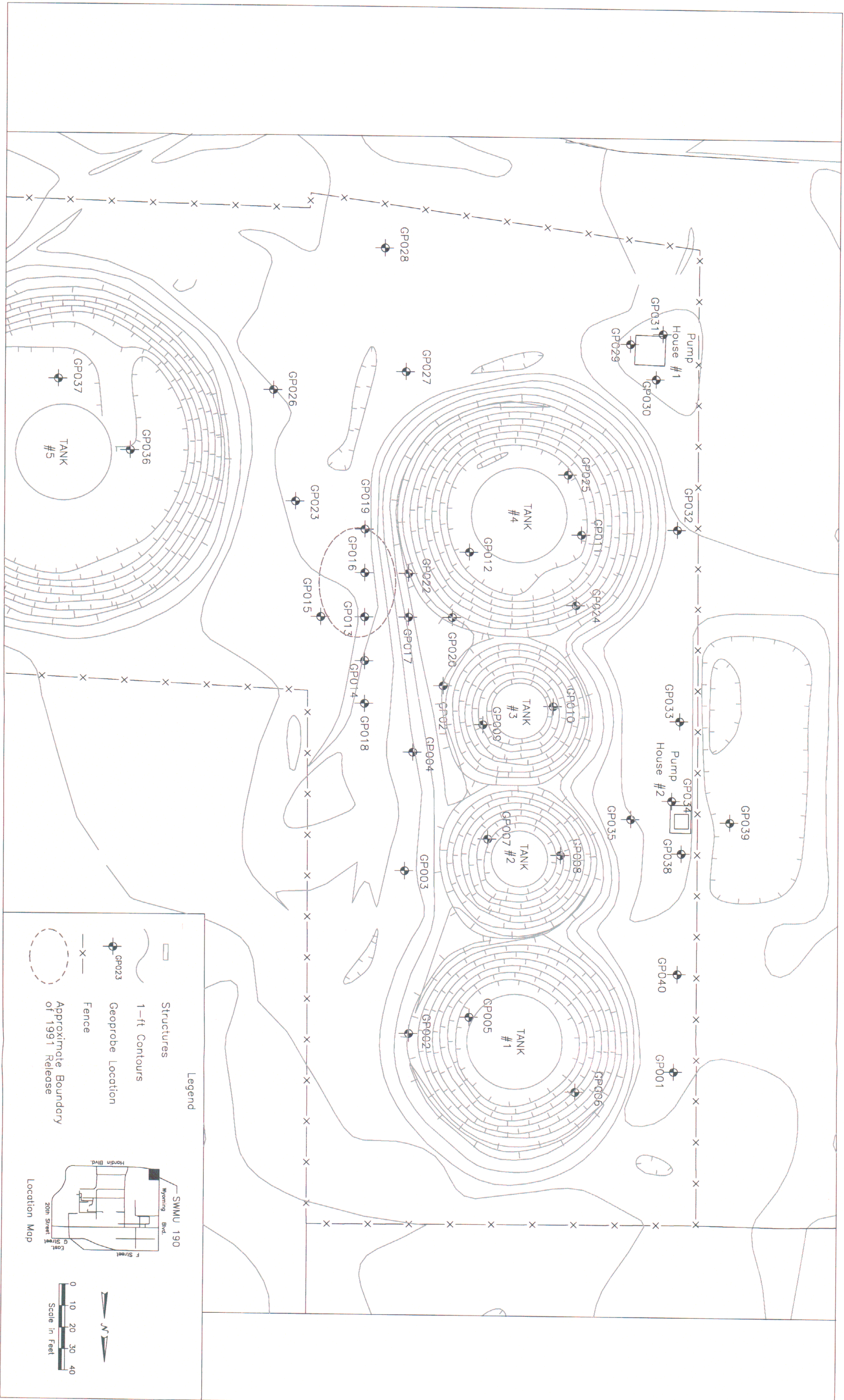


Figure 4.4.4-1
Geoprobe™ Locations
Investigation #3

samples were collected at the other 39 locations at depth intervals of 0 to 2, 3 to 5, 8 to 10 feet bgs, etc., until at least two consecutive 5-foot-depth intervals produced negative field screening results (less than the detection limit). When necessary, the Geoprobe™ sampling continued to the maximum attainable depth of 30 feet.

Field screening for TPH was conducted using an immunoassay method, specifically PETRO RISC kits by EnSys, Inc. Based upon the results of the field screening, selected samples were sent to on- and off-site laboratories to be analyzed for VOCs and TPH. The on-site laboratory used mass spectrometry to detect VOCs (U.S. Environmental Protection Agency [EPA] Methods 8240/8260) and TPH (EPA Method 8015—modified). The off-site laboratory analyzed the samples for VOCs (EPA Method 8240) and TPH (EPA Method 8015—modified) (EPA November 1986). The number of samples collected is as follows:

Analyses	Field Screening	ERCL	GEL
TPH (Immunoassay)	162	0	0
TPH (8015—modified)	0	120	27
VOCs (8240/8260)	0	120	27

ER = Environmental Restoration.

ERCL = ER Chemistry Laboratory.

GEL = General Engineering Laboratories Inc.

TPH = Total petroleum hydrocarbons.

VOC = Volatile organic compound.

Geoprobe™ sampling consisted of a hydraulic-driven probe that collected relatively undisturbed soil in acetate sleeves encased in a 3-foot-long stainless steel probe. The acetate sleeves were then removed from the probe, cut into appropriate sample lengths, capped, taped, and sent for field screening or laboratory analysis. Off-site TPH analysis required removing soil from the acetate sleeve and transferring the sample into a laboratory-supplied jar.

4.4.4.3 Data Gaps

The Geoprobe™ sampling was designed to identify locations for the deep soil boring (Investigation #5). Certain locations required further evaluation of the vertical extent of contamination.

4.4.4.4 Results and Conclusions

Immunoassay Technical Methodology and Analytical Results

The immunoassay analysis technique relies on an antibody that is developed specifically to be sensitive to the target compound. The antibodies in the PETRO RISC test kit are sensitive to gasoline, diesel, jet fuel, or used lubrication oils, but are not sensitive to potential interference compounds such as chlorinated solvents. The antibody's specificity triggers a sensitive colorimetric reaction, providing a visual interpretation of the result.

The immunoassay analysis itself is a four-step process that includes sample extraction, sample preparation, sample incubation, and interpretation of the result. Total run time is approximately

25 minutes per analysis, and several samples can be run at once. The results are determined by comparing the sample color to a standard using a photometer supplied by EnSys, Inc. The EPA has approved the PETRO RISC test kits for inclusion in the third update of Test Methods for Solid Waste, SW-846, under EPA Draft Method 4030 (EPA November 1986). Detection limits vary from 10 to 130 mg/kg, depending upon the hydrocarbon in question. The manufacturer states that this test method provides a detection level of 15 mg/kg (or 150 mg/kg by dilution) when used to detect fuel oil. According to the manufacturer's product information sheet, the test method produces an occurrence rate of less than 1 percent false negative results (i.e., the test reports a sample as "clean" when it is actually "dirty"). However, in order to achieve this low occurrence rate for false negatives, the test method reports a relatively high occurrence rate of false positives (i.e., the test reports a sample as "dirty" when it is actually "clean"). The occurrence rate for false positives is reported to be less than 11 percent, which implies that as many as one in ten positive results may be false.

Of the 162 TPH immunoassay analyses performed at the site, 14 showed positive results at greater than 15 mg/kg, and 6 showed positive results at greater than 150 mg/kg. The positive results were detected in various sample depth intervals from locations GP007, GP008, GP010, GP011, GP013, GP017, GP036, and GP038 (Table 4.4.4-1) (Van Deusen May 1995). The total depth of contamination could be determined for GP007 (10 feet), GP008 (10 feet), GP010 (2 feet), GP013 (10 feet), GP036 (2 feet), and GP038 (15 feet). The total depth of contamination could not be determined at GP011 or GP017, which produced detectable concentrations at the 30-foot depth at each location. These two locations contained five of the six total sample intervals that exceeded the upper (150 mg/kg) detection limit (Table 4.4.4-1).

On-Site Laboratory Results

The on-site laboratory performed TPH analyses on 120 soil samples. Eleven samples had detectable concentrations of TPH with values ranging from 98 to 49,000 (estimated J value) mg/kg (Table 4.4.4-2) (Lewis June 1995a). In this case, the "J" qualifier is associated with the highest concentrations of TPH and signifies that the observed value exceeded the calibration range of the analytical equipment (Kottenstette September 1995). Soil samples with detectable TPH were obtained from various depths at locations GP007, GP008, GP013, GP016, GP017, GP036, and GP038 (Table 4.4.4-2). The total depth of contamination was determined at all locations except for GP013 and GP017, which had detectable concentrations of TPH at the deepest sample interval at each location. The soil samples from the other 40 Geoprobe™ locations did not contain TPH above the detection limits of 50 mg/kg (Lewis June 1995a). In addition, the on-site laboratory performed VOC (EPA 8240/8260) analyses on the same set of 120 samples (EPA November 1986). No target analytes were detected in the soil samples (Lewis June 1995b) at the detection limits specified in Table 4.4.4-3.

Off-Site Laboratory Results

Twenty-seven soil samples (including two duplicates) were sent to an off-site laboratory (General Engineering Laboratories [GEL]) for confirmatory VOC analysis (EPA Method 8240) and TPH analysis (EPA Method 8015—modified). The TPH concentrations in the soil samples ranged from nondetect (in 12 samples) up to 52,100 mg/kg (Table 4.4.4-4). Acetone (up to 89.2 µg/kg) and methylene chloride (up to 133 µg/kg), both common laboratory contaminants, were detected in numerous samples (Table 4.4.4-5). No other VOCs were detected in the soil samples at the detection limits specified in Table 4.4.4-3.

Table 4.4.4-1
Summary of SWMU 190 RFI Geoprobe™ Soil Sampling (Investigation #3)
TPH Analytical Results—Detections Only
May 1995
(On-Site Laboratory Immunoassay Analysis)

Sample Attributes			TPH (Field Screening by Immunoassay ^a) (mg/kg)	
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	Detection Limit of 15	Detection Limit of 150
NA	TI190-GP007-010-S	8	>15	U (150)
NA	TI190-GP008-010-S	8	>15	U (150)
NA	TI190-GP010-002-S	0	>15	U (150)
NA	TI190-GP011-010-S	8	>15	U (150)
NA	TI190-GP011-015-S	13	>15	>150
NA	TI190-GP011-020-S	18	>15	>150
NA	TI190-GP011-030-S	28	>15	U (150)
NA	TI190-GP013-010-S	8	>15	U (150)
NA	TI190-GP017-015-S	13	>15	>150
NA	TI190-GP017-020-S	18	>15	U (150)
NA	TI190-GP017-025-S	23	>15	>150
NA	TI190-GP017-030-S	28	>15	>150
NA	TI190-GP036-002-S	0	>15	>150
NA	TI190-GP038-015-S	13	>15	U (150)

Note: Values in **bold** represent detected analytes.

^aSamples were analyzed by SNL/NM ER Chemistry Laboratory (Building 6540) using EnSys Inc., PETRO RISC test kits (Van Deusen May 1995).

^bAnalysis request/chain-of-custody record.

ER = Environmental Restoration.

ft = Foot (feet).

GP = Geoprobe™.

ID = Identification.

mg/kg = Milligram(s) per kilogram.

NA = Not applicable.

RCRA = Resource Conservation and Recovery Act.

RFI = RCRA Facility Investigation.

S = Soil sample.

SNL/NM = Sandia National Laboratories/New Mexico.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

TPH = Total petroleum hydrocarbons.

U = Analyte not detected above the method detection limit, shown in parentheses.

Table 4.4.4-2
Summary of SWMU 190 RFI Soil Sampling (Investigation #3)
TPH Analytical Results—Detections Only
May 1995
(On-Site Laboratory)

Sample Attributes			TPH (mg/kg)
Record Number ^a	ER Sample ID	Beginning Sample Depth (ft)	Diesel Fuel No. 2 ^b
3396	TI190-GP007-010-S	8	2,200 J
3396	TI190-GP008-010-S	8	490
3398	TI190-GP013-010-S	8	570 J
3398	TI190-GP013-015-S	13	98
3398	TI190-GP013-020-S	18	1,400 J
3400	TI190-GP016-005-S	3	1,500 J
3400	TI190-GP017-020-S	18	800 J
3400	TI190-GP017-025-S	23	2,500 J
3400	TI190-GP017-030-S	28	3,000 J
3508	TI190-GP036-002-SS ^c	0	49,000 J
3508	TI190-GP038-015-S	13	1,000 J

Note: Values in **bold** represent detected analytes.

^aAnalysis request/chain-of-custody record.

^bSamples analyzed by SNL/NM on-site ER Chemistry Laboratory and reported as Diesel 2 (Lewis 1995a).

^cFor GP036 the 2- and 5-ft samples were collected with a hand auger and were originally designated in the lab report as BH001.

BH = Borehole.

ER = Environmental Restoration.

ft = Foot (feet).

GP = Geoprobe™.

ID = Identification.

J = The associated value is either below the practical quantitation limit or above the highest calibration level and therefore is an estimated value ([sic] Lewis 1995a).

mg/kg = Milligram(s) per kilogram.

RCRA = Resource Conservation and Recovery Act.

RFI = RCRA Facility Investigation.

S = Soil sample.

SNL/NM = Sandia National Laboratories/New Mexico.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

TPH = Total petroleum hydrocarbons.

Table 4.4.4-3
 SWMU 190 RFI Soil Sampling (Investigations #3, #4, and #5)
 VOC Analytical Detection Limits
 May 1995–November 1996
 (On- and Off-Site Laboratories)

Analyte	Method Detection Limit (µg/kg)
1,1,1-Trichloroethane	1–2
1,1,2,2-Tetrachloroethane	1–2
1,1,2-Trichloroethane	1–2
1,1-Dichloroethane	1–2
1,1-Dichloroethene	1–5
1,2-Dichloroethane	1–2
1,2-Dichloropropane	1–2
1,2-trans-Dichloroethene	1
2-Butanone	2–10
2-Hexanone	2–10
4-methyl-, 2-Pentanone	2–10
Acetone	2–10
Benzene	1–2
Bromodichloromethane	1–2
Bromoform	1–5
Bromomethane	1–2
Carbon disulfide	2–5
Carbon tetrachloride	1–2
Chlorobenzene	1–2
Chlorodibromomethane	1
Chloroethane	1–2
Chloroform	1–2
Chloromethane	1–2
Dibromochloromethane	1–2
Ethyl benzene	1–2
Methylene chloride	1–2
Styrene	1–2
Tetrachloroethene	1–2
Toluene	1–2
Trichloroethene	1–2
Vinyl acetate	2–10
Vinyl chloride	1–5
Xylene	3–4
cis-1,2-Dichloroethene	1–2
cis-1,3-Dichloropropene	1–2
m-, p-Xylene	2
o-Xylene	1
trans-1,2-Dichloroethene	1–2
trans-1,3-Dichloropropene	1–2

µg/kg = Microgram(s) per kilogram.

RCRA = Resource Conservation and Recovery Act.

RFI = RCRA Facility Investigation.

SWMU = Solid Waste Management Unit.

VOC = Volatile organic compound.

Table 4.4.4-4
Summary of SWMU 190 RFI Soil Sampling (Investigation #3)
TPH Analytical Results—Detections Only
May 1995
(Off-Site Laboratory)

Sample Attributes			TPH (EPA Method 8015 ^a) (mg/kg)	
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	TPH—Nonvolatile Fraction	TPH—Volatile Fraction
3394	TI190-GP005-002-SS	0	2.8	ND (0.1)
3394	TI190-GP007-010-S	8	739	ND (0.1)
3394	TI190-GP008-010-S	8	139	ND (0.1)
3397	TI190-GP011-025-S	23	5.23	ND (0.1)
3397	TI190-GP013-020-S	18	637	ND (5)
3399	TI190-GP017-020-S	18	326	ND (2)
3399	TI190-GP021-020-S	18	5.2	0.116
3402	TI190-GP026-010-S	8	ND (0.361)	0.244
3402	TI190-GP026-012-S (duplicate)	8	ND (0.365)	0.223
3402	TI190-GP028-010-S	8	ND (0.362)	0.228
3402	TI190-GP029-010-S	8	ND (0.364)	0.133
3402	TI190-GP030-010-S	8	ND (0.363)	0.107
3509	TI190-GP036-001-SS	0	25,000	ND (2)
3509	TI190-GP036-002-SS (duplicate)	0	52,100	ND (1)
3510	TI190-GP039-010-S	8	3.33	ND (0.1)

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

^bAnalysis request/chain-of-custody record.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

GP = Geoprobe™.

ID = Identification.

ND () = Not detected above the method detection limit, shown in parentheses.

mg/kg = Milligram(s) per kilogram.

RCRA = Resource Conservation and Recovery Act.

RFI = RCRA Facility Investigation.

S = Soil sample.

SS = Surface soil sample.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

TPH = Total petroleum hydrocarbons.

Table 4.4.4-5
Summary of SWMU 190 RFI Soil Sampling (Investigation #3)
VOC Analytical Results—Detections Only
May 1995
(Off-Site Laboratory)

Sample Attributes			VOCs (EPA Method 8260 ^a) (µg/kg)	
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	Acetone	Methylene Chloride
3402	TI190-GP026-010-S	8	ND (20)	ND (2)
3402	TI190-GP026-012-S (duplicate)	8	ND (20)	2.9 J (10)
3402	TI190-GP028-010-S	8	ND (20)	2.6 J (10)
3402	TI190-GP030-010-S	8	ND (20)	2.5 J (10)
3402	TI190-GP031-010-S	8	ND (20)	2.8 J (10)
3402	TI190-GP032-010-S	8	ND (20)	2.5 J (10)
3402	TI190-GP033-010-S	8	ND (20)	2.5 J (10)
3509	TI190-GP036-001-SS	0	60.3	133
3509	TI190-GP036-002-SS (duplicate)	0	89.2	22.9
3509	TI190-GP036-010-S	8	10.7 J (20)	5.75 BJ (10)
3510	TI190-GP038-020-S	18	12.9 J (20)	5.11 BJ (10)
3510	TI190-GP039-010-S	8	12.4 J (20)	4.63 BJ (10)
Quality Assurance/Quality Control Samples (µg/L, unless otherwise noted)				
3402	TI190-TB003-W	NA	ND (10)	1.48 BJ (2)
3402	TI190-TB004-S (µg/kg)	NA	38.8	4.10 BJ (10)
3509	TI190-TB005-W	NA	ND (10)	8.16 B
3509	TI190-TB006-S (µg/kg)	NA	59.0	2.65 J (10)
3510	TI190-TB007-S (µg/kg)	NA	22.7	3.34 BJ (10)
3509	TI190-EB002-W	NA	ND (10)	4.37 B
3402	TI190-FB001-S (µg/kg)	NA	31.8	3.6 J (10)
3510	TI190-FB002-S (µg/kg)	NA	21.3	3.25 BJ (10)

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

^bAnalysis request/chain-of-custody record.

B = Analyte detected in an associated blank.

EB = Equipment blank.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

FB = Field blank.

ft = Foot (feet).

GP = Geoprobe™.

ID = Identification.

J () = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

µg/kg = Microgram(s) per kilogram.

µg/L = Microgram(s) per liter.

NA = Not applicable.

ND () = Not detected above the method detection limit, shown in parentheses.

RCRA = Resource Conservation and Recovery Act.

RFI = RCRA Facility Investigation.

S = Soil sample.

SS = Surface soil sample.

SWMU = Solid Waste Management Unit.

TB = Trip blank.

TI = Technical Area I.

VOC = Volatile organic compound.

W = Water sample.

4.4.5 Investigation #4—LIF/CPT Technology Demonstration

An LIF/CPT Technology Demonstration Project was conducted at the site as part of a formal program to accelerate acceptance and application of innovative monitoring and site-characterization technologies (EPA 1997a). The technology demonstration stakeholders included the EPA, the U.S. Department of Energy (DOE), and the U.S. Department of Defense (DOD). The U.S. Navy's Site Characterization and Analysis Penetrometer System (SCAPS) program spearheaded the technology development. The purpose of the demonstration was to facilitate the acceptance and use of the LIF/CPT technology for field screening of subsurface petroleum hydrocarbons. The demonstration was designed to compare LIF/CPT data to widely accepted conventional sampling and analytical methods. This comparison was made by over-boring LIF/CPT locations with hollow-stem auger drilling/split-spoon sampling. The LIF/CPT technology had been successfully demonstrated in a marine-coastal environment, but the stakeholders wished to verify success in a desert environment with a deep water table and a substantial thickness of vadose zone petroleum contamination (PRC August 1995).

The demonstration examined contaminant concentrations using the LIF sensor for petroleum detection. The sensor consists of a sapphire window used to transmit and return incident laser light and contaminant-induced fluorescence. The LIF is incorporated into a standard CPT system consisting of a truck, hydraulic rams and associated controllers, and the cone penetrometer. The cone penetrometer contains sensors that continuously log tip stress and sleeve friction. The tip stress and sleeve friction provide indices that can be used to generate a vertical profile of subsurface stratigraphy. The LIF uses a nitrogen laser to induce a fluorescence response in soil. The LIF sensor and cone penetrometer data are interpreted and plotted against depth by the on-board computer system. These data are then used to produce vertical profiles that display soil classification and fluorescence versus depth (EPA August 1995, EPA 1997a).

The demonstration was conducted in two phases during August and November 1995. In the first phase, SWMU 190 was pre-screened in a pilot study to determine an appropriate site for the formal demonstration. SWMU 190 was one of five desert sites in the southwest United States included in this pilot study. Based upon the favorable site conditions and the positive results of the pilot study, the site was chosen for the formal demonstration that was performed in November (second phase). The demonstration was conducted by personnel from the Naval Command, Control and Ocean Surveillance Center, Research, Development, Test, and Evaluation Division's SCAPS program (researchers, project managers, and technicians); PRC Environmental Management, Inc. (project managers, geologists, and technicians); SNL/NM Department 6621 (verification entity); and SNL/NM Department 7582 (health and safety oversight). Personnel from EPA (multiple regions), the Western Governors Association, DOD, DOE, and the New Mexico Environment Department (NMED) were present to oversee the demonstration. The demonstrated technologies are evaluated elsewhere (EPA 1997a). However, the soil sampling analytical results are relevant to the NFA Proposal and are discussed below.

4.4.5.1 Nonsampling Data Collection

There were no nonsampling data collection activities associated with Investigation #4 at SWMU 190.

4.4.5.2 Sampling Data Collection

Phase 1

The first phase of the LIF/CPT investigation was completed between August 16 and 18, 1995. It consisted of five SCAPS LIF/CPT pushes and three soil-sample pushes in the vicinity of the June 1991 fuel-oil release (Figure 4.4.5-1). The procedures and methods used to conduct the work are thoroughly discussed in the proposed work plan (PRC August 1995). The SCAPS LIF/CPT pushes met refusal at a depth of approximately 52 to 56 feet bgs in what was thought to be a caliche zone (PRC September 1995). The SCAPS LIF/CPT pushes (P01 through P05) and soil-sample pushes (S01 through S03) were collected adjacent to previous Geoprobe™ locations from the May 1995 sampling event (GP013, GP015, GP016, and GP018). Due to the presence of the steep-sided berm and the limitations of the SCAPS rig, the most highly contaminated Geoprobe™ location (GP017) could not be accessed for a SCAPS LIF/CPT push. At each location, the SCAPS LIF/CPT push was conducted and the profiles plotted in the field. The LIF data indicated the presence of petroleum hydrocarbons in the vadose zone in three of the pushes (P01, P03, and P04). The data also found no fluorescent impact above background levels in two of the pushes (P02 and P05) (PRC September 1995).

At select locations, three discrete soil samples were collected at depth: S01 (52 feet), S02 (52 feet), and S03 (43 feet). Based upon the SCAPS LIF/CPT field plot, two samples (one thought to be clean [S03] and one thought to be contaminated [S02]), were sent to Analytical Technologies, Inc. (ATI) in San Diego, California, for laboratory analysis. The two samples were analyzed for total recoverable petroleum hydrocarbons (TRPH) by EPA Method 418.1 and for TPH by EPA Method 8015—modified. Sample S01 (which did not get sent to ATI) and a split sample of S02 also were sent to the on-site analytical laboratory and were analyzed for VOCs by EPA Method 8240/8260 and for TPH by EPA Method 8015—modified (EPA November 1986).

Phase 2

The second phase, conducted November 1 through November 8, 1995, consisted of the formal demonstration. In addition to the SCAPS LIF/CPT pushes and the sampling, the formal demonstration also tested an independently developed technology very similar to SCAPS LIF/CPT, called the Rapid Optical Screening Tool (ROST) system by LORAL Corporation. The SCAPS LIF/CPT and ROST data were tested against discrete soil samples collected by hollow-stem auger and split-spoon sampling. A number of SCAPS LIF/CPT and ROST pre-demonstration pushes (DP01 through DP09) and samples (DS01 and DS02) were completed from November 1 to November 3, 1995, at locations adjacent to existing Geoprobe™ locations from the May 1995 sampling event (Figure 4.4.5-2). The berm around the most highly contaminated Geoprobe™ location (GP017) was removed to allow access for the SCAPS rig.

From November 6 through November 8, 1995, the formal demonstration was conducted at three locations (Figure 4.4.5-2). Each location included SCAPS LIF/CPT pushes (DP10 through DP12), ROST pushes (DR10 through DR12), and hollow-stem auger boreholes (DB10 through DB12). The locations were supposed to represent conditions ranging from highly contaminated (DP11, DR11, and DB11) to moderately contaminated (DP10, DR10, and DB10) to not contaminated

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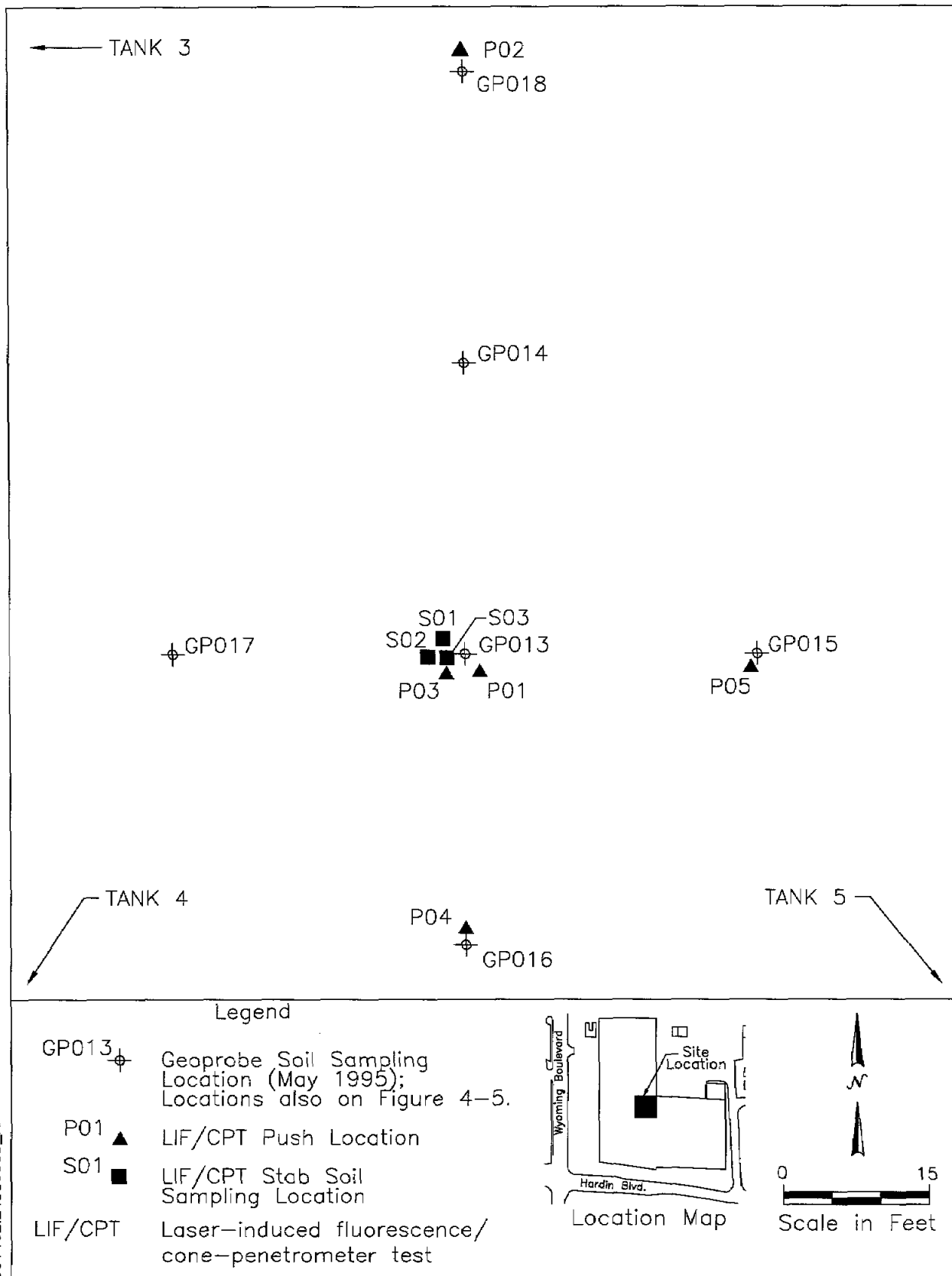
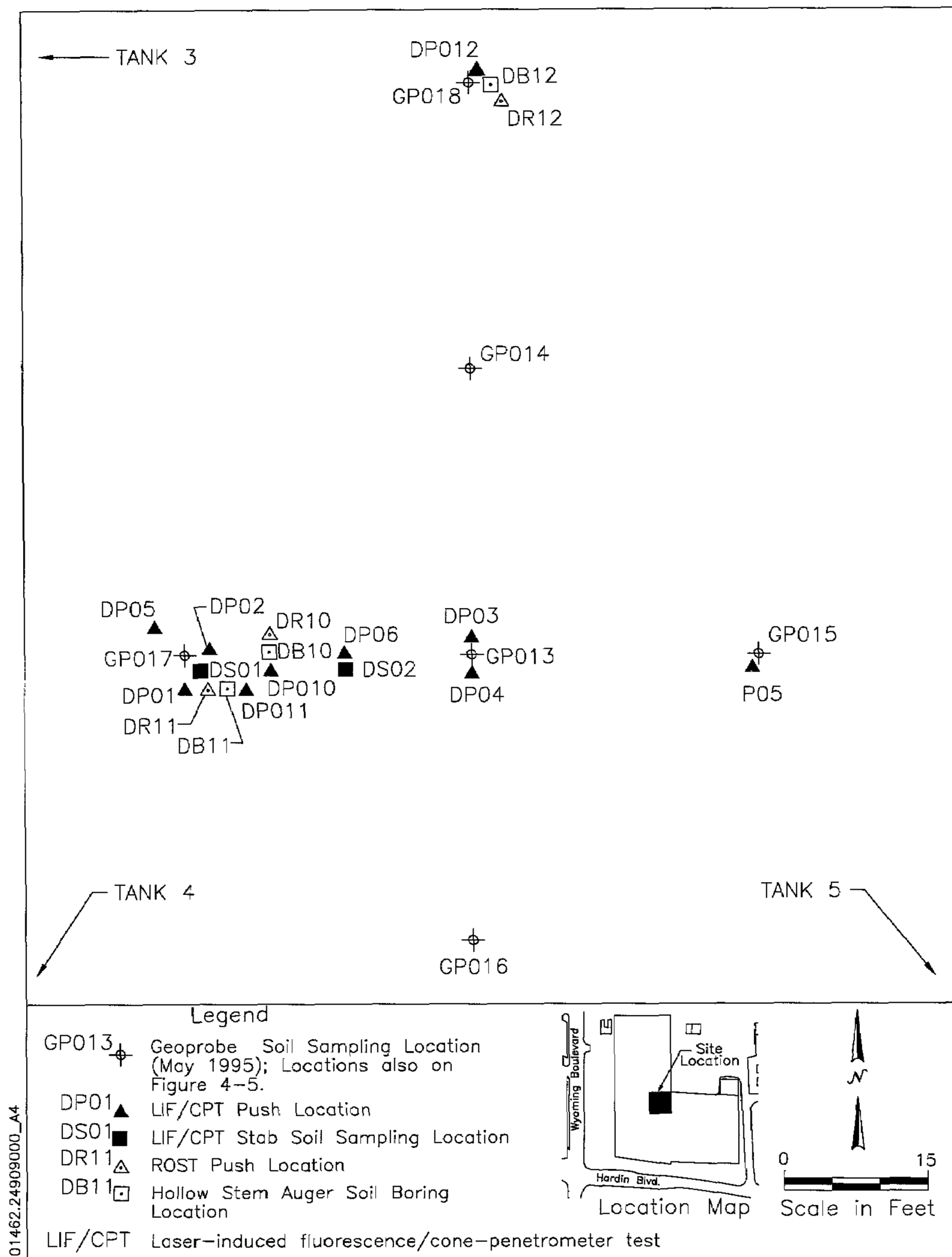


Figure 4.4.5-1
LIF/CPT Demonstration Program Sampling Locations (August 1995)
Investigation #4, Phase 1



(DP12, DR12, and DB12). As with the SCAPS LIF/CPT pushes in August, the maximum push depth was around 55 feet bgs. Borehole DB12 was continuously sampled 4 to 5 feet beyond the SCAPS LIF/CPT and ROST push refusal depth. The soil samples revealed that the refusal was due to an extensive and thick layer of gravel.

4.4.5.3 *Data Gaps*

Investigation #4 was not designed to determine the horizontal and vertical extent of contamination at SWMU 190.

4.4.5.4 *Results and Conclusions*

Phase 1

The on- and off-site laboratory analytical results for the three Phase 1 soil samples are summarized in Table 4.4.5-1. All analytical results were nondetect for samples S01 and S03. As determined by ATI, Sample S02 exhibited 12,600 mg/kg of TRPH and TPH results of less than 250 mg/kg for gasoline-range and 21,000 mg/kg diesel-range (Table 4.4.5-1). As determined by the on-site analytical laboratory, Sample S02 had minor hits of acetone (5.1 J µg/mg), ethylbenzene (3.2 J µg/kg), p/m-xylenes (12 µg/kg), o-xylene (22 µg/kg), as well as a TPH value of 31,500 J mg/kg (Table 4.4.5-1). The results of the laboratory data indicated that contaminated soil near GP013 in the area of the June 1991 pipeline rupture are present at deeper intervals than the depth obtained by the May 1995 Geoprobe™ sampling (Investigation #3). The wide range of TPH concentrations from samples collected in close proximity and at similar depths shows the erratic distribution of TPH in subsurface soils.

Phase 2

Numerous soil samples were collected from the borehole locations for laboratory analysis by ATI in California. The analytical results presented in Table 4.4.5-2 show gross contamination to the total depth of boreholes DB10 and DB11 (labeled SNLDB-10 and SNLDB-11 on Table 4.4.5-2). Concentrations ranged from nondetect to 44,600 mg/kg of TRPH. The ATI results for SNLDB-12 from 3 to 50 feet bgs were all nondetect. Two additional samples were collected from near the bottom of borehole SNLDB-12 (at 54 and 58 feet bgs identified as TI190-DB012-054 and TI190-DB012-058) and sent to the on-site analytical laboratory for TPH analysis (EPA Method 8015—modified). Both samples were nondetect (<50 mg/kg) (Lewis December 1995).

4.4.6 *Investigation #5—1996 Deep Borehole Sampling*

The deep-borehole sampling was completed in November 1996 and consisted of drilling and collecting soil samples with a dual-wall, casing-hammer drill rig at locations identified during the RFI near-surface Geoprobe™ sampling (Investigation #3).

Table 4.4.5-1
Summary of SWMU 190 LIF/CPT Demonstration Soil Sampling (Investigation #4, Phase 1)
TPH and VOC Analytical Results—Detections Only
August 1995
(On- and Off-Site Laboratories)

Sample Attributes			Off-Site Laboratory ^a			On-Site Laboratory ^b	
Record Number ^c	PRC Sample ID and ER Sample ID	Beginning Sample Depth (ft)	TRPH ^d (mg/kg)	TPH ^e Gasoline Range (mg/kg)	TPH Diesel Range (mg/kg)	TPH (mg/kg)	VOCs ^f (µg/kg)
508960	SL190S01 (aka TI190-CPT003-054)	51.5	NA	NA	NA	ND (<50)	All ND (MDLs of 1 to 5)
PRC 4428 508960	SL190S02 (aka TI190-CPT004-051)	51.5	12,600	<250	21,000	31,500 J	Acetone – 5.1 J Ethylbenzene – 3.2 J m-,p-Xylenes – 12 o-Xylene – 22
PRC 4428	SL190S03	43	ND (<1)	ND (<5)	ND (<5)	NA	NA

Note: Values in **bold** represent detected analytes.

^aSamples analyzed by ATI Laboratory in San Diego, California (PRC December 1995).

^bERCL (Kottenstette September 1995).

^cAnalysis request/chain-of-custody record.

^dTRPH analysis based upon EPA Method 418.1.

^eTPH analysis based upon EPA Method 8015—modified (EPA November 1986).

^fVOC analyses based upon EPA Method 8260 (EPA November 1986).

aka = Also known as.

ATI = Analytical Technologies, Inc.

CPT = Cone Penetrometer Test.

ER = Environmental Restoration.

EPA = U.S. Environmental Protection Agency.

ERCL = Environmental Restoration Chemical Laboratory.

ft = Foot (feet).

ID = Identification.

J = The associated value is either below the practical quantitation limit or above the highest calibration level and therefore is an estimated value ([sic] Lewis 1995a).

LIF/CPT = Laser-Induced Fluorescence/Cone Penetrometer Test.

MDL = Method detection limit.

µg/kg = Microgram(s) per kilogram.

mg/kg = Milligram(s) per kilogram.

NA = Not analyzed.

ND () = Not detected above the method detection limit, shown in parentheses.

PRC = PRC Environmental Management, Inc.

SL = Sandia National Laboratories/New Mexico.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

TPH = Total petroleum hydrocarbons.

TRPH = Total recoverable petroleum hydrocarbons.

VOC = Volatile organic compound.

Table 4.4.5-2
Summary of SWMU 190 LIF/CPT Demonstration Soil Sampling (Investigation #4, Phase 2)
TPH Analytical Results^a
November 1996
(Off-Site Laboratory)

Sample Attributes		TRPH Concentration (mg/kg)	TPH Diesel Concentration (mg/kg)
Location	End Depth (ft)		
SNLDB-10	3.0	60	23
	3.5	25	ND (<5)
	5.0	89	99
	5.5	42	54
	7.0	71	70
	7.5	162	150
	9.0	17	ND (<5)
	9.5	11	14
	11.0	27	24
	11.5	22	27
	13.0	206	270
	13.5	1,470	1,500
	15.0	4,870	5,000
	15.5	7,600	6,600
	17.0	14,300	21,000
	17.5	8,500	13,000
	19.0	25,600	26,000
	19.5	25,800	28,000
	21.0	14,700	14,000
	21.5	5,790	6,300
	23.0	6,530	6,900
	23.5	8,560	9,100
	25.0	5,100	4,200
	25.5	5,400	4,500
	27.0	11,200	9,800
	29.0	20,400	20,000
	29.5	24,900	23,000
	31.0	7,330	6,600
	31.5	3,520	3,100
	33.0	1,340	1,400
	33.5	28,400	35,000
	35.0	25,600	24,000
	35.5	18,200	18,000
	37.0	9,620	10,000
	37.5	26,200	21,000
	39.0	32,200	28,000
	39.5	21,700	21,000
	41.0	15,800	14,000

Refer to footnotes at end of table.

Table 4.4.5-2 (Continued)
Summary of SWMU 190 LIF/CPT Demonstration Soil Sampling (Investigation #4, Phase 2)
TPH Analytical Results^a
November 1996
(Off-Site Laboratory)

Sample Attributes		TRPH Concentration (mg/kg)	TPH Diesel Concentration (mg/kg)
Location	End Depth (ft)		
SNLDB-10 (continued)	41.5	8,440	9,700
	43.0	9,500	12,000
	43.0 (Duplicate)	9,160	12,000
	43.5	15,000	18,000
	45.0	7,500	12,000
	45.5	11,000	9,900
	47.0	13,000	15,000
	47.5	19,000	23,000
	49.0	26,000	32,000
	49.5	8,200	14,000
	51.0	13,000	14,000
	51.5	15,000	27,000
	53.0	17,000	12,000
	53.5	5,500	8,500
	56.0	21,000	28,000
	56.25	5,000	7,700
SNLDB-11	6.25	9.7	19
	11.0	9.0	ND (<5)
	11.5	ND (<1)	ND (<5)
	16.25	3,470	2,700
	21.0	13,000	11,000
	21.5	15,200	21,000
	26.0	12,000	10,000
	26.5	22,300	21,000
	31.0	18,200	17,000
	33.5	31,000	21,000
	36.0	19,800	19,000
	36.5	22,200	21,000
	41.0	26,200	24,000
	41.5	5,160	4,200
	43.0	20,600	22,000
	43.5	18,300	22,000
	45.0	7,030	14,000
	45.5	6,240	10,000
	47.0	11,900	13,000
	47.5	25,400	29,000
	48.5	17,200	29,000

Refer to footnotes at end of table.

Table 4.4.5-2 (Concluded)
Summary of SWMU 190 LIF/CPT Demonstration Soil Sampling (Investigation #4, Phase 2)
TPH Analytical Results^a
November 1996
(Off-Site Laboratory)

Sample Attributes		TRPH Concentration (mg/kg)	TPH Diesel Concentration (mg/kg)
Location	End Depth (ft)		
SNLDB-11 (continued)	49.0	44,600	39,000
	49.5	7,340	8,900
	51.0	14,700	14,000
	51.5	23,600	25,000
	53.0	16,100	16,000
	53.5	13,600	13,000
	55.25	21,400	20,000
SNLDB-12	all depths to 50 ft	ND	ND

Note: Values in **bold** represent detected analytes.

^aSamples analyzed by ATI Laboratory in San Diego, California (PRC December 1995).

ATI = Albuquerque Technology Incubator.

ft = Foot (feet).

LIF/CPT = Laser-Induced Fluorescence/Cone Penetrometer Test.

mg/kg = Milligram(s) per kilogram.

ND = Not detected above the method detection limit (unspecified).

ND () = Not detected above the method detection limit, shown in parentheses.

SNLDB = Sandia National Laboratories demonstration boring.

SWMU = Solid Waste Management Unit.

TPH = Total petroleum hydrocarbons.

TRPH = Total recoverable petroleum hydrocarbons.

4.4.6.1 *Nonsampling Data Collection*

No nonsampling data collection activities were conducted as part of Investigation #5.

4.4.6.2 *Sampling Data Collection*

Samples were collected from eight locations at the site (BH100 through BH107) (Figure 4.4.6-1), starting at 34 to 36 feet bgs to depths as great as 109 to 111 feet bgs, depending upon field screening results. On- and off-site laboratories analyzed samples for VOCs, SVOCs, and TPH. Additionally, immunoassay-based test kits were used at all locations to screen for TPH. A total of 83 soil samples were collected, including 7 for off-site analysis, 23 for on-site analysis, and 53 for immunoassay field screening. These totals do not include quality assurance/quality control or waste management samples.

In accordance with the strategy specified in the RFI Work Plan, deep borehole soil samples were collected within the site from two different areas that exhibited TPH contamination during the near-surface soil-sampling program (SNL/NM June 1996). The boreholes were located in the area of the known fuel-oil release (near GP013 and GP017) (Figure 4.4.6-1) and in an area discovered during the near-surface soil sampling investigation (near GP011). Samples were collected at 5-foot-depth intervals from 36 to 51 feet bgs, and thereafter at 10-foot intervals, until at least two consecutive depth intervals produced negative field screening results.

The sampling procedure utilized a down-hole, hammer-driven split-spoon that collected relatively undisturbed soil in stainless-steel sleeves within a 2-foot-long sampler. The sleeves were then removed, capped and taped, and sent to either the on- or off-site laboratory for TPH and VOC analysis. Samples for the immunoassay field screening were collected in the same manner and hand-delivered to a temporary field laboratory for immediate analysis. Soil samples obtained for off-site SVOC and VOC analysis were collected by removing the soil sample from the sleeves and transferring the sample into a laboratory-supplied jar.

Soil samples collected from the site were sent to an off-site laboratory and analyzed for VOCs (EPA Method 8240) and TPH (EPA Method 8015—modified), with selected samples also analyzed for SVOCs (EPA 8270). The on-site laboratory used mass spectrometry to analyze for VOCs and TPH. The immunoassay analysis technique used PETRO RISC kits by EnSys, Inc.

4.4.6.3 *Data Gaps*

No data gaps were identified in Investigation #5.

4.4.6.4 *Results and Conclusions*

Immunoassay Technical Methodology and Analytical Results

The immunoassay analysis technique used for the deep-borehole investigation was the same as that used for the near-surface investigation. For explanation of technical methodology, see Section 4.4.4.4.

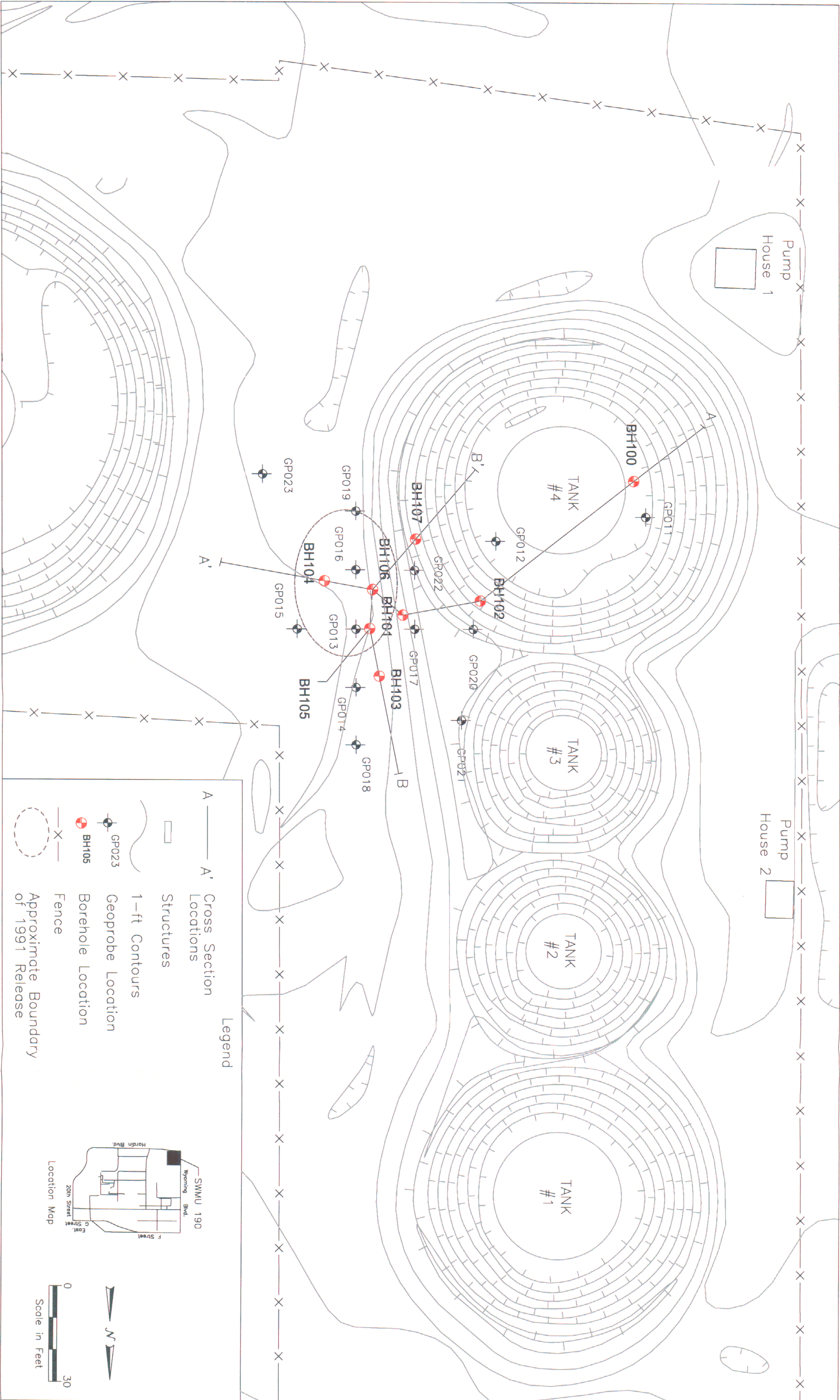


Figure 4.4.6-1
Geoprobe™ (Investigation #3) & Borehole Samples (Investigation #4),
Locations and Cross Sections.

Of the 53 TPH immunoassay analyses performed at the site, 13 samples showed positive results at greater than 15 mg/kg, and 11 samples showed positive results at greater than 150 mg/kg (original results from BH101-091, BH107-046, and BH107-051 are thought to be false positives; see discussion below). The positive hits were found in various sample intervals from locations BH101, BH105, and BH106 (Table 4.4.6-1) (Capitan December 1996). The total depth of contamination was determined at all locations exhibiting contaminated soils.

The deepest contamination was found at BH101, with concentrations above the 15 mg/kg detection limit found at the 79-foot depth. Locations BH101, BH105, and BH106 contained three to five sample intervals (up to a 40-foot thickness) that exceeded the 150 mg/kg detection limit (Table 4.4.6-1). All other TPH immunoassay analyses from the other five locations resulted in nondetects.

As mentioned above, the original results from BH101-091, BH107-046, and BH107-051 are attributed to the built-in false positive in the immunoassay method. Each of the three initial sample analyses led to the impossible conclusion that the soils had TPH concentrations of less than 15 mg/kg and greater than 150 mg/kg. Due to these suspicious results, the samples were reanalyzed as BH101-091R, BH107-046R, and BH107-051R. The repeat analysis showed that the soils were free of TPH contamination at both the 15 and 150 mg/kg detection levels. A false negative response is also evident in comparing the results for samples collected at the 41-foot depth in borehole BH101. The data show detectable concentrations in the 15 mg/kg immunoassay method and no detectable concentrations in the 150 mg/kg immunoassay method, but 7,200 mg/kg in the on-site laboratory TPH analysis (discussed below).

On-Site Laboratory Results

The on-site laboratory performed TPH (EPA Method 8015—modified) analysis on 23 soil samples collected (Table 4.4.6-2) (Lewis January 1997a, 1997b, 1997c). Of the 23 TPH analyses performed, 3 showed positive results, with values ranging from 270 to 8,600 mg/kg. TPH was detected in the soil samples obtained from 39-, 44-, and 69-foot sample intervals for locations BH101, BH105, and BH106, respectively (Table 4.4.6-2). The total depth of contamination was determined at each of these locations with two clean (no detectable TPH) samples collected from below the soil intervals with detectable TPH.

In addition, the on-site laboratory performed VOC (EPA 8240/8260) analyses on the same set of 23 samples. Seven different analytes were reported from eleven samples (Table 4.4.6-3) (Lewis January 1997a, 1997b, 1997c) with acetone and 2-butanone, both common laboratory contaminants, being the most frequently detected analytes. BTEX (benzene, toluene, ethylbenzene, and xylenes) compounds were detected in two samples (BH105-046 and BH106-071) with o-xylene having the greatest concentration of 220 µg/kg (also the sample with the maximum TPH concentration).

Off-site Laboratory Results

Seven soil samples were sent to an outside laboratory (GEL) for independent analysis for VOC (EPA 8240) and TPH (EPA Method 8015—modified). In addition, SVOCs (EPA Method 8270) were analyzed for a select group of five samples. GEL reported the TPH data as "nonvolatile

Table 4.4.6-1
Summary of SWMU 190 RFI Deep Borehole Soil Sampling (Investigation #5)
TPH Analytical Results—Detections Only
November 1996
(On-Site Laboratory Immunoassay Analysis)

Sample Attributes			TPH (Field Screening by Immunoassay ^a) (mg/kg)	
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	Detection Limit of 15	Detection Limit of 150
NA	TI190-BH101-036-S	34	>15	>150
NA	TI190-BH101-041-S	39	>15	U (150)
NA	TI190-BH101-046-S	44	>15	>150
NA	TI190-BH101-051-S	49	>15	>150
NA	TI190-BH101-071-S	69	>15	>150
NA	TI190-BH101-081-S	79	>15	U (150)
NA	TI190-BH105-036-S	34	>15	>150
NA	TI190-BH105-046-S	44	>15	>150
NA	TI190-BH105-051-S	49	>15	>150
NA	TI190-BH105-073-S	71	>15	>150
NA	TI190-BH106-051-S	49	>15	>150
NA	TI190-BH106-063-S	61	>15	>150
NA	TI190-BH106-071-S	69	>15	>150

Note: Values in **bold** represent detected analytes.

^aSamples were analyzed by SNL/NM ER Chemistry Laboratory using EnSys Inc., PETRO RISC test kits (Capitan December 1996).

^bAnalysis request/chain-of-custody record.

BH = Borehole.

ER = Environmental Restoration.

ft = Foot (feet).

ID = Identification.

mg/kg = Milligram(s) per kilogram.

NA = Not applicable.

RCRA = Resource Conservation and Recovery Act.

RFI = RCRA Facility Investigation.

S = Soil sample.

SNL/NM = Sandia National Laboratories/New Mexico.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

TPH = Total petroleum hydrocarbons.

U = Analyte not detected above the method detection limit, shown parentheses.

Table 4.4.6-2
Summary of SWMU 190 Deep Borehole Soil Sampling (Investigation #5)
TPH Analytical Results—Detections Only
November 1996
(On-Site Laboratory)

Sample Attributes		TPH (EPA Method 8015 ^a) mg/kg	
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	Diesel Fuel No. 2 ^c
5574	TI190-BH101-041-S	39	7,200
5130	TI190-BH105-046-S	44	8,600
5130	TI190-BH106-071-S	69	270

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

^bAnalysis request/chain-of-custody record.

^cSamples analyzed by on-site SNL/NM ER Chemistry Laboratory and reported as Diesel 2.

BH = Borehole.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

ID = Identification.

mg/kg = Milligram(s) per kilogram.

S = Soil sample.

SNL/NM = Sandia National Laboratories/New Mexico.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

TPH = Total petroleum hydrocarbons.

Table 4.4.6-3
Summary of SWMU 190 Deep Borehole Soil Sampling (Investigation #5)
VOC Analytical Results—Detections Only
November 1996
(On-Site Laboratory)

Sample Attributes			VOCs (EPA Method 8260 ^a) (µg/kg)						
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	2-Butanone	Acetone	Benzene	Ethyl benzene	Toluene	m-, p-Xylene	o-Xylene
5574	TI190-BH100-039-S	37	ND (5)	7.6 J (20)	ND (1)	ND (1)	ND (1)	ND (2)	ND (1)
5575	TI190-BH103-051-S	49	ND (5)	5.6 J (20)	ND (1)	ND (1)	ND (1)	ND (2)	ND (1)
5130	TI190-BH105-046-S	44	43	42	2.2 J (4)	ND (1)	34	ND (2)	220
5130	TI190-BH105-091-S	89	18 J (20)	ND (5)	ND (1)	ND (1)	ND (1)	ND (2)	ND (1)
5130	TI190-BH105-101-S	99	19 J (20)	7 J (20)	ND (1)	ND (1)	ND (1)	ND (2)	ND (1)
5130	TI190-BH106-071-S	69	130	340	ND (1)	12	ND (1)	33	21
5130	TI190-BH106-091-S	89	14 J (20)	7.8 J (20)	ND (1)	ND (1)	ND (1)	ND (2)	ND (1)
5130	TI190-BH106-101-S	99	13 J (20)	8.6 J (20)	ND (1)	ND (1)	ND (1)	ND (2)	ND (1)
5130	TI190-BH107-046-S	44	15 J (20)	8.9 J (20)	ND (1)	ND (1)	ND (1)	ND (2)	ND (1)
5130	TI190-BH107-051-S	49	18 J (20)	7.3 J (20)	ND (1)	ND (1)	ND (1)	ND (2)	ND (1)
5130	TI190-BH107-081-S	79	14 J (20)	8 J (20)	ND (1)	ND (1)	ND (1)	ND (2)	ND (1)

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

^bAnalysis request/chain-of-custody record.

BH = Borehole.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

ID = Identification.

J () = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

µg/kg = Microgram(s) per kilogram.

ND () = Not detected above the method detection limit, shown in parentheses.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

VOC = Volatile organic compound.

fraction" and "volatile fraction". These fractions represent the diesel-range hydrocarbons and the gasoline-range hydrocarbons, respectively. It should be noted that the nonvolatile fraction is reported as mg/kg while the volatile fraction is reported as µg/kg.

The TPH analytical results ranged from nondetect in the volatile fraction (for five samples) to 4,300 B mg/kg for one nonvolatile fraction analysis (Table 4.4.6-4). The "B"-qualifier signifies that the analyte also was detected in the laboratory method blank. Overall, TPH was detected in low concentrations (less than 2 mg/kg) in four of the samples, and at levels of concern (greater than 50 mg/kg) in three samples (BH101-046, BH101-071, and BH105-046).

VOC analytical results indicated the presence of 2-butanone, acetone, methylene chloride, ethylbenzene, and xylene (total) in the soil samples (Table 4.4.6-5). Acetone and methylene chloride are the most frequently detected analytes. It should be noted that acetone, 2-butanone, and methylene chloride are common laboratory contaminants. The BTEX compounds were detected in two samples (BH101-046 and BH105-046) with xylene (total) exhibiting the maximum concentration of 212 µg/kg, showing good correlation with the highest TPH-volatile fraction results.

As required by the RFI Work Plan, the SVOC analyses were completed in order to characterize degradation of the fuel oil in soil. At BH101, SVOC samples were collected from highly contaminated soil (at 46 feet), moderately contaminated soil (at 71 feet), and noncontaminated soil (at 101 and 111 feet). An additional SVOC sample was collected from BH105-046 to further characterize the highly contaminated soil. The SVOCs 2-methylnaphthalene, dibenzofuran, fluorene, and phenanthrene were detected in the contaminated samples (Table 4.4.6-6). The maximum concentration of SVOCs in an analyte was phenanthrene from BH105-046 with 7,720 µg/kg. Numerous SVOCs were detected in the associated equipment blank (Table 4.4.6-6). No other target SVOC analytes were detected in the soil samples at the detection limits specified in Table 4.4.6-7.

4.4.7 Investigation #6—Investigation Associated with the Installation of the Remediation System

Based upon subsurface investigations described above, an EC/VCM Plan was prepared for SNL/NM by Roy F. Weston, Inc. (Weston) in the fall of 1998 (Weston October 1998). All previous investigations showed that the only significant contamination at SWMU 190 was at the site of the known pipeline rupture. The EC/VCM proposed to construct a bioventing system to remediate the subsurface fuel-oil contamination at this location.

Weston constructed the bioventing system during the fall and winter of 1998 and early 1999. The system contains four extraction wells, screened in different geologic formations, in the center of the contamination plume (Figure 4.4.7-1). Four vent wells (VW-001 through VW-004) were constructed around the perimeter of the plume. A blower, used to remove air from the extraction wells (EW-001 through EW-004), creates regions of low pressure. The induced pressure gradient provides oxygen to the subsurface to enhance aerobic degradation of the contamination. The concept behind the bioventing process is to enhance aerobic microorganism growth in the subsurface to expedite the chemical breakdown of the hydrocarbons (fuel oil). The microorganisms use the energy created from the oxidation-reduction reaction to create new cells. Because the supply of oxygen is critical to the production of new cell material, the bioventing system installed at SWMU 190 is designed to deliver

Table 4.4.6-4
Summary of SWMU 190 Deep Borehole Soil Sampling (Investigation #5)
TPH Analytical Results—Detections Only
November 1996
(Off-Site Laboratory)

Sample Attributes			TPH (EPA Method 8015 ^a)	
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	TPH—Nonvolatile Fraction (mg/kg)	TPH—Volatile Fraction (µg/kg)
5573	TI190-BH100-39-S	37	0.951 BJ (1.18)	ND (25)
5573	TI190-BH101-046-S	44	897 B	1,530
5573	TI190-BH101-071-S	69	61.4 B	ND (25)
5573	TI190-BH101-101-S	99	1.28 B	ND (25)
5573	TI190-BH101-111-S	109	0.621 BJ (0.661)	ND (25)
5710	TI190-BH105-046-S	44	4,300 B	2,430
5710	TI190-BH105-091-S	89	0.485 B	ND (25)

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

^bAnalysis request/chain-of-custody record.

B = Analyte detected in an associated blank.

BH = Borehole.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

ID = Identification.

J = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit.

µg/kg = Microgram(s) per kilogram.

mg/kg = Milligram(s) per kilogram.

ND () = Not detected above the method detection limit, shown in parentheses.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

TPH = Total petroleum hydrocarbons.

Table 4.4.6-5
 Summary of SWMU 190 Deep Borehole Soil Sampling (Investigation #5)
 VOC Analytical Results—Detections Only
 November 1996
 (Off-Site Laboratory)

Sample Attributes		VOCs (EPA Method 8260 ^a) (µg/kg)						
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	1,1-Dichloroethene	2-Butanone	Acetone	Benzene	Chlorobenzene	Chloromethane
5573	TI190-BH100-39-S	37	ND (1)	ND (2)	8.6 J (10)	ND (1)	ND (1)	ND (1)
5573	TI190-BH101-046-S	44	ND (1)	87.5	115	ND (1)	ND (1)	ND (1)
5573	TI190-BH101-071-S	69	ND (1)	ND (2)	159	ND (1)	ND (1)	ND (1)
5573	TI190-BH101-101-S	99	ND (1)	ND (2)	ND (2)	ND (1)	ND (1)	ND (1)
5710	TI190-BH105-046-S	44	ND (1)	ND (2)	173	ND (1)	ND (1)	ND (1)
5710	TI190-BH105-091-S	89	ND (1)	ND (2)	5.6 J (10)	ND (1)	ND (1)	ND (1)
Quality Assurance/Quality Control Samples (µg/L, unless otherwise noted)								
5710	TI190-EB100-W	NA	18.1	ND (2)	12.7	19.9	22.2	ND (1)
5710	TI190-FB-100-S (µg/kg)	NA	24.6	2.95 J (5)	26.7	16.5	20	ND (1)
5710	TI190-TB100-S (µg/kg)	NA	ND (1)	7.36	25.3	ND (1)	ND (1)	1.26 J (2)
5710	TI190-TB100-W	NA	ND (1)	ND (2)	5.2 J (10)	ND (1)	ND (1)	ND (1)

Refer to footnotes at end of table.

Table 4.4.6-5 (Concluded)
Summary of SWMU 190 Deep Borehole Soil Sampling (Investigation #5)
VOC Analytical Results—Detections Only
November 1996
(Off-Site Laboratory)

Sample Attributes		VOCs (EPA Method 8260 ^a) (µg/kg)						
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	Ethyl benzene	Methylene chloride	Styrene	Toluene	Trichloroethene	Xylene
5573	TI190-BH100-39-S	37	ND (1)	1.1 J (10)	ND (1)	ND (1)	ND (1)	ND (3)
5573	TI190-BH101-046-S	44	15	ND (1)	ND (1)	ND (1)	ND (1)	192
5573	TI190-BH101-071-S	69	ND (1)	5.5 J (10)	ND (1)	ND (1)	ND (1)	ND (3)
5573	TI190-BH101-101-S	99	ND (1)	1.4 J (10)	ND (1)	ND (1)	ND (1)	ND (3)
5710	TI190-BH105-046-S	44	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	212
5710	TI190-BH105-091-S	89	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (3)
Quality Assurance/Quality Control Samples (µg/L, unless otherwise noted)								
5710	TI190-EB100-W	NA	ND (1)	ND (1)	ND (1)	21.5	19.2	ND (3)
5710	TI190-FB-100-S (µg/kg)	NA	ND (1)	7.01 B	ND (1)	1.28 J (2)	23.7	ND (3)
5710	TI190-TB100-S (µg/kg)	NA	ND (1)	4.7 B J (5)	1.02 J (2)	ND (1)	ND (1)	ND (3)
5710	TI190-TB100-W	NA	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (3)

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

^bAnalysis request/chain-of-custody record.

B = Analyte detected in an associated blank.

BH = Borehole.

EB = Equipment blank.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

FB = Field blank.

ft = Foot (feet).

ID = Identification.

J () = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

µg/kg = Microgram(s) per kilogram.

µg/L = Microgram(s) per liter.

NA = Not applicable.

ND () = Not detected above the method detection limit, shown in parentheses.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TB = Trip blank.

TI = Technical Area I.

VOC = Volatile organic compound.

W = Water sample.

Table 4.4.6-6
Summary of SWMU 190 Deep Borehole Soil Sampling (Investigation #5)
SVOC Analytical Results—Detections Only
November 1996
(Off-Site Laboratory)

Sample Attributes			SVOCs (EPA Method 8270 ^a) (µg/kg)			
Record Number ^b	ER Sample ID	Sample Depth (ft)	1,2,4-Trichlorobenzene	1,4-Dichlorobenzene	2,4-Dinitrotoluene	2-Chlorophenol
5573	TI190-BH101-046-S	44	ND (167)	ND (167)	ND (167)	ND (167)
5573	TI190-BH101-071-S	69	ND (167)	ND (167)	ND (167)	ND (167)
5710	TI190-BH105-046-S	44	ND (167)	ND (167)	ND (167)	ND (167)
Quality Assurance/Quality Control Sample (µg/L)						
5710	TI190-EB100-W	NA	52.1	49.8	42.7	76.1

Sample Attributes			SVOCs (EPA Method 8270 ^a) (µg/kg)			
Record Number ^b	ER Sample ID	Sample Depth (ft)	2-Methylnaphthalene	4-Chloro-3-methylphenol	4-Nitrophenol	Acenaphthene
5573	TI190-BH101-046-S	44	2,460 J (3,290)	ND (167)	ND (333)	ND (167)
5573	TI190-BH101-071-S	69	2,990	ND (167)	ND (333)	ND (167)
5710	TI190-BH105-046-S	44	7,280	ND (167)	ND (333)	ND (167)
Quality Assurance/Quality Control Sample (µg/L)						
5710	TI190-EB100-W	NA	ND (5)	88.4	30.2	49.2

Sample Attributes			SVOCs (EPA Method 8270 ^a) (µg/kg)			
Record Number ^b	ER Sample ID	Sample Depth (ft)	Dibenzofuran	Fluorene	Pentachlorophenol	Phenanthrene
5573	TI190-BH101-046-S	44	2,330 J (3,290)	ND (167)	ND (167)	6,970
5573	TI190-BH101-071-S	69	678 J (1,330)	ND (167)	ND (167)	1,490
5710	TI190-BH105-046-S	44	3,530	3,590	ND (167)	7,720
Quality Assurance/Quality Control Sample (µg/L)						
5710	TI190-EB100-W	NA	ND (5)	ND (5)	73.4	ND (5)

Refer to footnotes at end of table.

Table 4.4.6-6 (Concluded)
 Summary of SWMU 190 Deep Borehole Soil Sampling (Investigation #5)
 SVOC Analytical Results—Detections Only
 November 1996
 (Off-Site Laboratory)

Sample Attributes			SVOCs (EPA Method 8270 ^a) (µg/kg)			
Record Number ^b	ER Sample ID	Sample Depth (ft)	Phenol	Pyrene	bis(2-Ethylhexyl)phthalate	n-Nitrosodipropylamine
5573	TI190-BH101-046-S	44	ND (167)	ND (167)	ND (167)	ND (167)
5573	TI190-BH101-071-S	69	ND (167)	ND (167)	ND (167)	ND (167)
5710	TI190-BH105-046-S	44	ND (167)	ND (167)	ND (167)	ND (167)
Quality Assurance/Quality Control Sample (µg/L)						
5710	TI190-EB100-W	NA	59.1	46.2	25.1	57.1

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

^bAnalysis request/chain-of-custody record.

BH = Borehole.

EB = Equipment blank.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

ID = Identification.

J () = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

µg/kg = Microgram(s) per kilogram.

µg/L = Microgram(s) per liter.

NA = Not applicable.

ND () = Not detected above the method detection limit, shown in parentheses.

S = Soil sample.

SVOC = Semivolatile organic compound.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

W = Water sample.

Table 4.4.6-7
 SWMU 190 Deep Borehole Soil Sampling (Investigation #5)
 SVOC Analytical Detection Limits
 November 1996
 (Off-Site Laboratory)

Analyte	Method Detection Limit (µg/kg)
1,2,4-Trichlorobenzene	167
1,2-Dichlorobenzene	167
1,3-Dichlorobenzene	167
1,4-Dichlorobenzene	167
2,4,5-Trichlorophenol	167
2,4,6-Trichlorophenol	167
2,4-Dichlorophenol	167
2,4-Dimethylphenol	167
2,4-Dinitrophenol	333
2,4-Dinitrotoluene	167
2,6-Dinitrotoluene	167
2-Chloronaphthalene	167
2-Chlorophenol	167
2-Methylnaphthalene	167
2-Nitroaniline	167
2-Nitrophenol	167
3,3'-Dichlorobenzidine	833
3-Nitroaniline	200
4-Bromophenyl phenyl ether	167
4-Chloro-3-methylphenol	167
4-Chlorobenzenamine	200
4-Chlorophenyl phenyl ether	167
4-Nitroaniline	167
4-Nitrophenol	333
Acenaphthene	167
Acenaphthylene	167
Anthracene	167
Benzo(a)anthracene	167
Benzo(a)pyrene	167
Benzo(b)fluoranthene	167
Benzo(ghi)perylene	167
Benzo(k)fluoranthene	167
Benzoic acid	333
Benzyl alcohol	167
Butylbenzyl phthalate	167
Chrysene	167
Di-n-butyl phthalate	167
Di-n-octyl phthalate	167
Dibenz[a,h]anthracene	167
Dibenzofuran	167
Diethylphthalate	167
Dimethylphthalate	167
Dinitro-o-cresol	167

Refer to footnotes at end of table.

Table 4.4.6-7 (Concluded)
 SWMU 190 Deep Borehole Soil Sampling (Investigation #5)
 SVOC Analytical Detection Limits
 November 1996
 (Off-Site Laboratory)

Analyte	Method Detection Limit (µg/kg)
Fluoranthene	167
Fluorene	167
Hexachlorobenzene	167
Hexachlorobutadiene	167
Hexachlorocyclopentadiene	167
Hexachloroethane	167
Indeno(1,2,3-c,d)pyrene	167
Isophorone	167
Naphthalene	167
Nitro-benzene	167
Pentachlorophenol	167
Phenanthrene	167
Phenol	167
Pyrene	167
bis(2-Chloroethoxy)methane	167
bis(2-Chloroethyl)ether	167
bis(2-Ethylhexyl)phthalate	167
bis-Chloroisopropyl ether	167
m,p-Cresol	167
n-Nitrosodiphenylamine	167
n-Nitrosodipropylamine	167
o-Cresol	167

µg/kg = Microgram(s) per kilogram.
 SVOC = Semivolatile organic compound.
 SWMU = Solid Waste Management Unit.

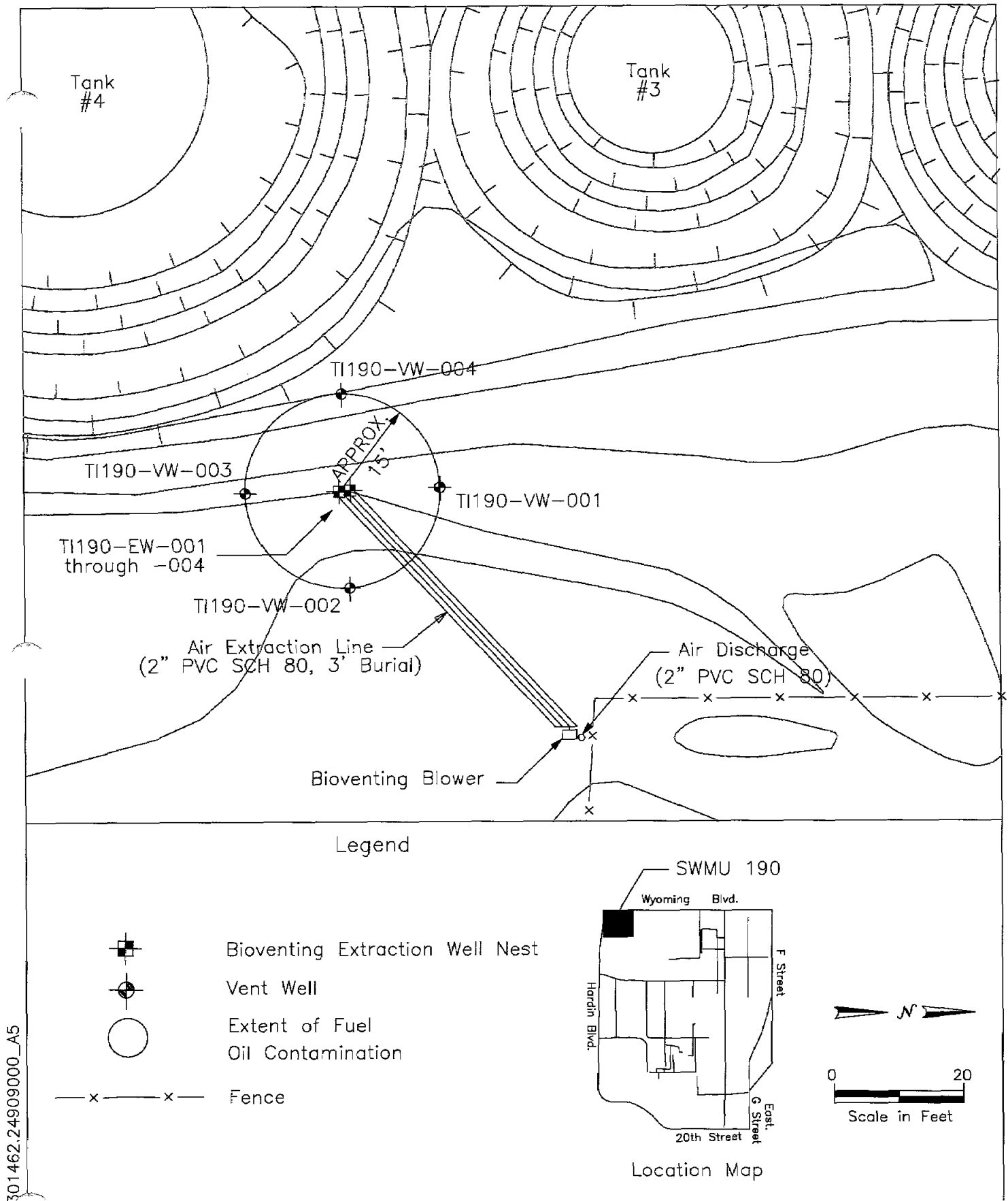


Figure 4.4.7-1
Bioventing System Layout, Investigation #6 - SWMU 190
Expedited Cleanup/Voluntary Corrective Measure

additional oxygen to the subsurface microorganisms to accelerate aerobic reaction and breakdown of the fuel oil.

Soil samples extracted during borehole advancement were analyzed for TPH using EPA Method 8015—modified. Details regarding the design and construction of the remediation system were provided in the EC/VCM Plan (Weston October 1998). The information in this NFA proposal is limited to the soil sample analytical results and descriptions of the site geology generated during the preparation of the EC/VCM Plan.

4.4.7.1 Nonsampling Data Collection

In support of the EC/VCM, two geologic cross sections were constructed to show subsurface geology in the area of contamination at the Tank Farm (cross section locations are shown on Figure 4.4.6-1). The two cross sections, A-A' and B-B' in Figures 4.4.7-2 and 4.4.7-3 present stratigraphy evident from eight boreholes drilled in November 1996 and from near-surface geology (0 to 30 feet) from Geoprobe™ boreholes completed in May 1995.

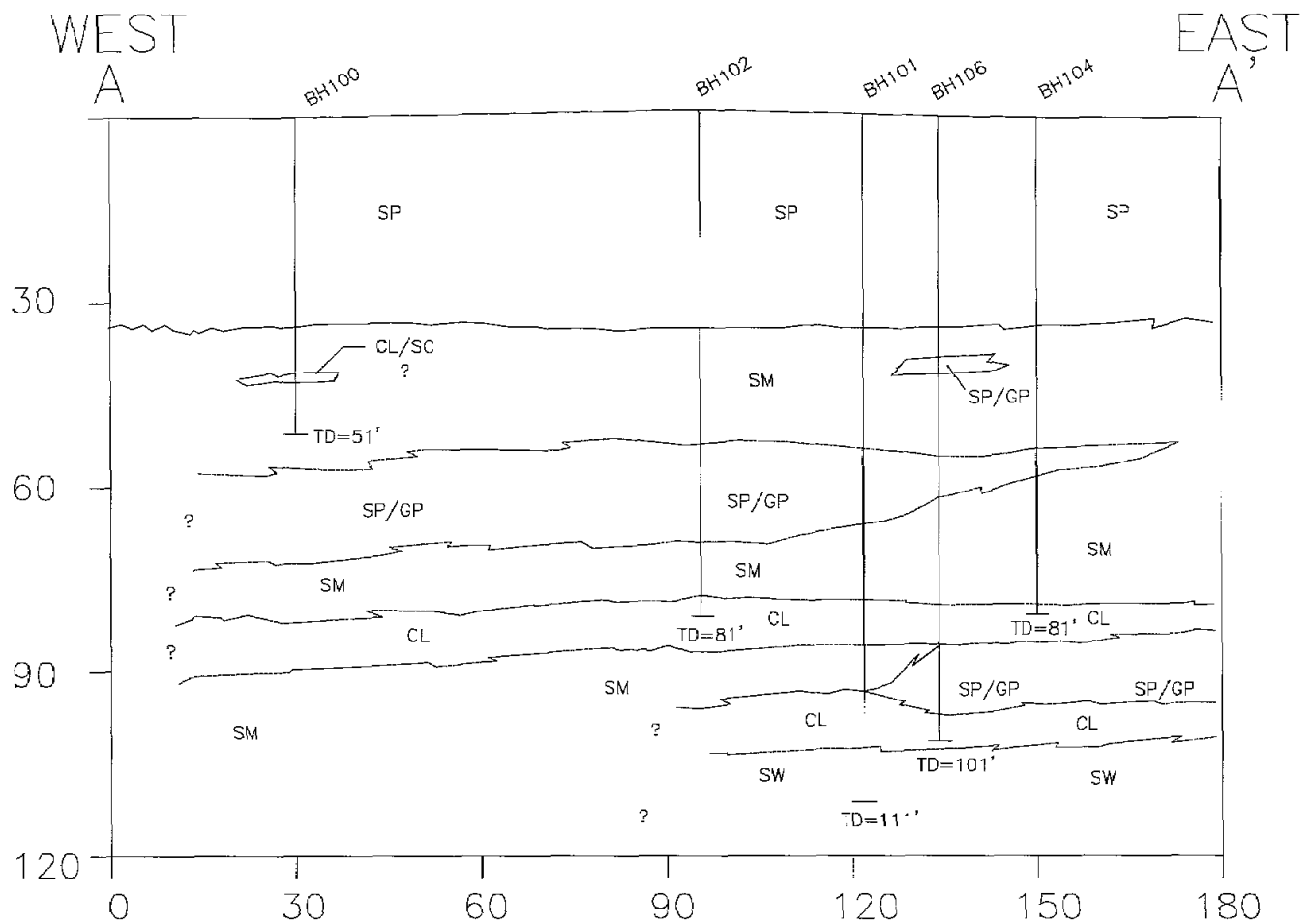
Cross section A-A' shows a west-to-east profile through the AOC and cross section B-B' a south-to-north profile. Total depth of boreholes varied from 51 to 111 feet. All cross sections reveal a general layered stratigraphy of sands, silty sands, sandy gravels, and clays to silty clays. The sands are present from ground surface to 32 feet bgs and the silty sands from 32 to 54 feet bgs and from approximately 66 to 80 feet bgs. Sandy gravels and gravelly sands are sandwiched between the silty sand layers. A 4- to 7-foot-thick clay-to-silty-clay layer begins at 78 feet bgs and another clay layer begins at 94 to 97 feet bgs. Sandwiched between the clay layers is a 10- to 12-foot-thick layer of silty sands to sandy gravels. The upper clay layer is considered to be a good confining boundary unit (as supported by contaminant data) that impedes downward contaminant migration.

Estimated contaminated soil volumes were calculated for four separate units within the subsurface and used to optimize the bioventing system. Data obtained from the subsurface investigations was used to delineate a contamination plume containing approximately 14,069 cubic feet of contaminated soil within four distinguishable geologic layers (Weston October 1998). The bioventing system design was based upon a cylindrical TPH plume with a 15-foot radius and an 80-foot depth (Figure 4.4.6-1).

4.4.7.2 Sampling Data Collection

A total of six borings were advanced through the subsurface and completed as wells (Figure 4.4.6-1). Extraction and venting wells were advanced using a dual-tube percussion rig with a 9-inch outer diameter casing. Four borings were completed as vent wells on the perimeter of the fuel-oil plume and designated VW-001 through VW-004. Two borings were completed as four extraction wells (two completions nested in each borehole) near the center of the plume and designated EW-001 through EW-004. For all of the soil borings, soil samples were extracted at 10-foot-depth intervals with a 2-foot-drive, split-spoon sampler. Soil was described and inspected for signs of hydrocarbon contamination. A Thermo-Environmental photo-ionization detector with a 10.2 electron volt lamp was used to field-screen samples as described in "Headspace Field Method," Appendix C, 20 NMAC 5.12, New Mexico Underground Storage Tank Regulations (NMED April 1995). This data was used only for qualitative

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Notes:

1. West A - East A' Borehole Cross Section
2. No Vertical Exaggeration
3. Lithologic designators are based on unified soil classification system (USCS)

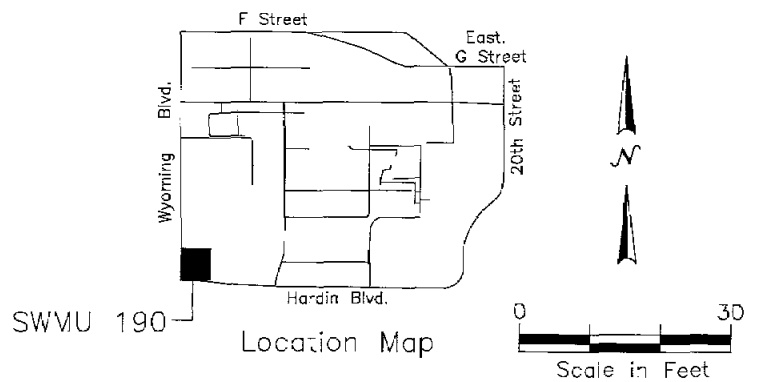
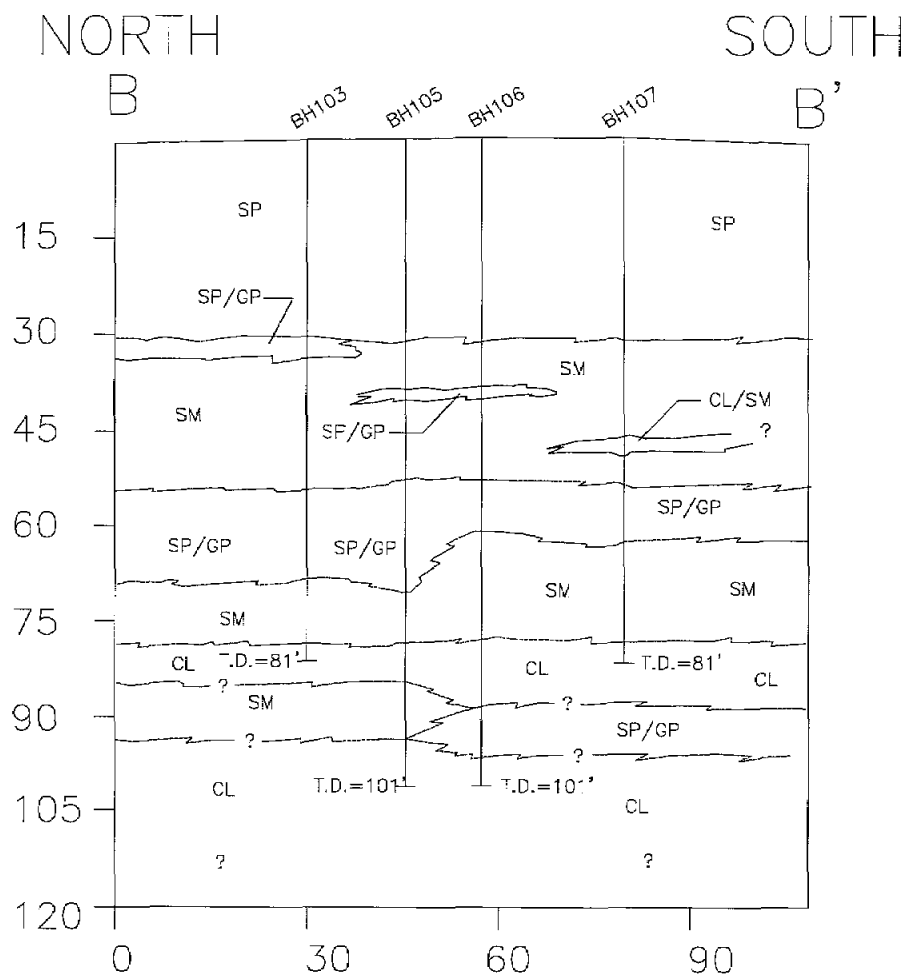


Figure 4.4.7-2
Cross Section A-A'



Notes:

1. North (B) - South (B') Borehole Cross Section
2. No Vertical Exaggeration
3. Lithologic designators are based on unified soil classification system (USCS)

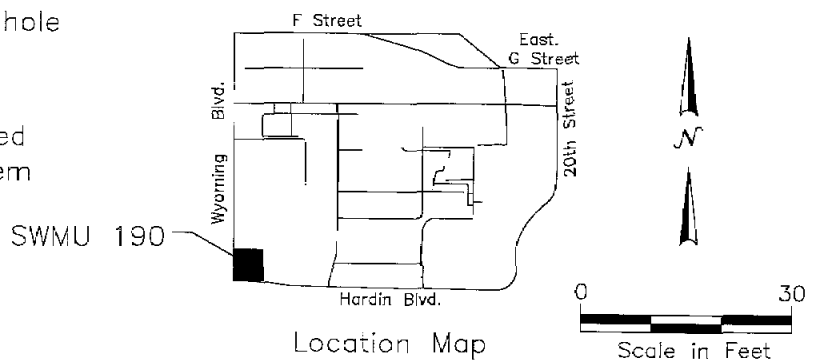


Figure 4.4.7-3
Cross Section B-B'

purposes. Headspace analysis is used for lighter, more volatile petroleum products (such as gasoline), but does provide a general idea of the magnitude of contamination present in the soil from the fuel oil.

Soil samples were extracted for laboratory analysis at both on-site (SNL/NM ER Chemistry Laboratory, Building 6540) and off-site (CORE Laboratory, Denver, Colorado) facilities. Samples were tested for TPH using EPA Method 8015—modified for fuel oil.

4.4.7.3 *Data Gaps*

No data gaps were identified by Investigation #6. The effectiveness of the remediation system has not been evaluated. The system was designed and installed as part of the ER Projects best management practices to encourage biological degradation of COCs. This NFA proposal is based solely upon the pre-VCM soil concentrations, therefore the lack of verification is not considered a data gap.

4.4.7.4 *Results and Conclusions*

The samples collected as part of the installation of the remediation system agree with plume delineation estimates based upon previous subsurface investigations. The results shown in Tables 4.4.7-1 and 4.4.7-2 indicate TPH concentrations from 64 J to 30,000 mg/kg for the on-site laboratory and 0.15 J to 2,600 mg/kg for the off-site laboratory within the center of the plume (samples from the extraction well boreholes). TPH concentration at a depth of 80 feet was reported as less than the method detection limit (MDL) of 27 mg/kg, within the deeper of the extraction well boreholes, and less than 27 mg/kg at the shallow depths of 10 feet. This indicates the vertical boundary of the contamination plume is near 80 feet bgs. Vent wells were designed to be installed in clean soil, outside the horizontal boundary of the contamination plume. As expected, samples from the vent well boreholes were less than the MDL of 30 mg/kg; with the exception of a few locations that intercepted a small portion of the plume, as indicated with positive readings of TPH (i.e., TI190-VW-003-020-S, TI190-VW-004-040-S, TI190-VW-004-060-S).

4.4.8 *Investigation #7—Sampling of On-Site Groundwater Monitoring Wells*

As described in Section 4.1.1, groundwater monitoring for the area surrounding SWMU 190 is conducted as part of the TAG Investigation (SNL/NM March 1996). Two water-bearing zones, the shallow groundwater system and the regional aquifer, underlie SWMU 190. Two monitoring wells, TAI-W-01 (the regional aquifer well) and TAI-W-07 (the shallow groundwater system well), are located immediately north of Tank 1 within the boundaries of SWMU 190 (Figure 4.1-1). Well completion diagrams for these two wells are provided in Annex 4-A.

The depth to the shallow groundwater system is approximately 275 feet bgs at TAI-W-07. This groundwater is not used for water supply purposes in the vicinity of the site. The southeasterly slope of the potentiometric surface indicates that TAI-W-07 is slightly upgradient of the fuel-oil release, and the nearest downgradient well in the shallow groundwater system is TA2-NW1-325 (Annex 4-A) located approximately one-half mile southeast of SWMU 190.

Table 4.4.7-1
Summary of SWMU 190 EC/VCM Soil Sampling (Investigation #6)
TPH Analytical Results—Detections Only
October 1998
(On-Site Laboratory)

Sample Attributes		TPH (EPA Method 8015 ^a) (mg/kg)	
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	Diesel Range Organics
600867	TI190-EW-001-020-S	18	18,000
600867	TI190-EW-001-030-S	28	17,000
600867	TI190-EW-001-040-S	38	12,000
600867	TI190-EW-001-050-S	48	11,000
600867	TI190-EW-001-060-S	58	4,900
600867	TI190-EW-001-070-S	68	30,000
600868	TI190-EW-003-020-S	18	11,000
600868	TI190-EW-003-030-S	28	3,800
600868	TI190-EW-003-040-S	38	9,300
600868	TI190-EW-003-050-S	48	3,700
600871	TI190-VW-003-010-S	08	91 J (110)
600871	TI190-VW-003-020-S	18	440
600872	TI190-VW-004-040-S	38	3,800
600872	TI190-VW-004-060-S	58	860
600872	TI190-VW-004-070-S	68	64 J (110)

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

^bAnalysis request/chain-of-custody record.

EC/VCM = Expedited Cleanup/Voluntary Corrective Measure.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

EW = Extraction well.

ft = Foot (feet).

ID = Identification.

J () = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

mg/kg = Milligram(s) per kilogram.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

TPH = Total petroleum hydrocarbons.

VW = Vent well.

Table 4.4.7-2
Summary of SWMU 190 EC/VCM Soil Sampling (Investigation #6)
TPH Analytical Results—Detections Only
October 1998
(Off-Site Laboratory)

Sample Attributes		TPH (EPA Method 8015 ^a) (mg/kg)	
Record Number ^b	ER Sample ID	Beginning Sample Depth (ft)	Total Extractable Petroleum Hydrocarbons
600873	TI190-EW-001-020-S	18	2,400
600873	TI190-EW-001-030-S	28	2,600
600873	TI190-EW-003-030-S	28	510
600873	TI190-EW-003-090-S	88	300
600875	TI190-VW-001-050-S	48	0.15 J (0.5)
600875	TI190-VW-004-040-S	38	830
600875	TI190-VW-004-070-S	68	9

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

^bAnalysis request/chain-of-custody record.

EC/VCM = Expedited Cleanup/Voluntary Corrective Measure.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

EW = Extraction well.

ft = Foot (feet).

ID = Identification.

J () = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

mg/kg = Milligram(s) per kilogram.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TI = Technical Area I.

TPH = Total petroleum hydrocarbons.

VW = Vent well.

The depth to the regional aquifer at TAI-W-01 is approximately 535 feet bgs. The northwesterly slope of the potentiometric surface of the regional aquifer in the vicinity of the site indicates that TAI-W-01 is downgradient of the fuel-oil release. Both the City of Albuquerque and KAFB use the regional aquifer as a water supply source, and pumping of city wells has created a cone of depression in the northern portion of SNL/NM that affects groundwater flow in the regional aquifer in the vicinity of the site. The nearest regional-aquifer water-supply well is KAFB-1, located approximately one-half mile northwest of the site.

Results for multiple sampling events at these monitoring wells have been reported in TAG Investigation Annual Reports (for example SNL/NM March 1998 and June 2000) produced by the ER Project, or the Annual Groundwater Monitoring Report produced by the SNL/NM Groundwater Protection Program, (for example, SNL/NM March 2000). These results are summarized in Section 4.4.8.4.

4.4.8.1 *Nonsampling Data Collection*

Numerous nonsampling investigations have been completed in support of hydrogeologic conceptual model studies for the TAG study area including: lithologic logging, borehole geophysics, colloidal borescope, surface geophysics, and geologic mapping. Description of the plans and results of these investigations are discussed in detail in the SNL/NM groundwater monitoring and investigation annual reports (SNL/NM March 1996, SNL/NM March 1998, SNL/NM March 2000, and SNL/NM June 2000).

4.4.8.2 *Sampling Data Collection*

Since 1993, groundwater sampling has been performed on a quarterly basis at wells spatially related to SWMU 190 (Table 4.4.8-1). Groundwater sampling has included analysis for VOCs and SVOCs.

Table 4.4.8-1
Groundwater Sampling Summary (Investigation #7) for Wells in or Near SWMU 190

Well	First Date Sampled	Number of SVOC Sampling Events	Number of SVOCs Detected	Number of VOC Sampling Events	Number of VOCs Detected
TAI-W-01	December 1997	6	0	17	3
TAI-W-07	December 1998	3	1	12	1
TA2-NW1-325	March 1993	15	2	28	5

NW = Northwest.
SVOC = Semivolatile organic compound.
SWMU = Solid Waste Management Unit.
TA = Technical area.
VOC = Volatile organic compound.
W = West.

All groundwater samples were collected using dedicated low-flow sample pumps (QED Micro Purge™). Each pump is located at the midpoint of the well screen as recommended by the manufacturer. Groundwater is purged at flow rates of approximately 0.1 L per minute from the well. Samples were collected for laboratory analyses after water quality parameters had stabilized. Groundwater samples were collected from the pump discharge tube directly into laboratory-prepared sample containers.

Collection of field analytical measurements were performed in accordance with Field Operating Procedure (FOP) 94-46, "Field Analytical Measurement of Groundwater" (SNL/NM September 1999) and FOP 94-34 "Field Sample Management and Custody" (SNL/NM April 1995). Groundwater temperature, specific conductance, pH, and oxidation/reduction potential (Eh) were measured using a YSI™ Model 3500 Water Quality Meter. Turbidity was measured with a Hach Model 2100P portable turbidity meter. Water quality measurements were recorded on Field Measurement Log forms. Groundwater pH, temperature, specific conductance, turbidity, and Eh were measured during purging and after completion of sampling.

4.4.8.3 Data Gaps

No data gaps were identified by Investigation #7.

4.4.8.4 Results and Conclusions

With only sporadic detections of minor concentrations of VOCs and SVOCs, groundwater does not appear to have been impacted by the fuel-oil release at SWMU 190. For the regional aquifer well (TAI-W-01), three VOCs have been detected at low, mainly estimated concentrations in two sampling events (Table 4.4.8-2) and include: acetone; 2-Hexanone; and 4-methyl-, 2-pentanone. These compounds have been detected at or near the MDLs and are not compounds usually considered to be associated with fuel oil. No SVOCs have been detected in this well.

For the on-site shallow groundwater well (TAI-W-07), only one VOC (1,1-dichloroethene) has been detected in six sampling events at low, estimated concentrations (Table 4.4.8-3) with values at or near the MDL. In addition, only one SVOC (di-n-octyl phthalate) was detected during one sampling event at a concentration below the MDL. The downgradient shallow groundwater system well (TA2-NW1-325) has had multiple VOC and SVOC detections during sampling events, including acetone, di-n-butyl phthalate, bis(2-ethylhexyl)phthalate, methylene chloride, tetrachloroethene, toluene, trichloroethene (Table 4.4.8-4) at concentrations at or near the MDL. With the exception of toluene, these compounds are not usually considered to be associated with fuel oil. Toluene was detected only once in October 1994 at an extremely low concentration (2 µg/L). Toluene has not been detected in TA2-W-NW1-325 in 22 subsequent sampling events.

Plume delineation estimates based upon previous subsurface soil investigations showed the maximum depth of fuel-oil contamination to be limited to vadose zone soil approximately 195 feet above the shallow groundwater system and 455 feet above the regional aquifer. The groundwater sampling analytical results provide further evidence that the depth to groundwater at the site has precluded migration of residual fuel-oil COCs to groundwater. Thus, no contamination of groundwater has occurred nor is any expected to occur.

Table 4.4.8-2
Summary of SWMU 190 Groundwater Sampling (Investigation #7)
VOC and SVOC Analytical Results—Detections Only
Monitoring Well TAI-W-01
(On- and Off-Site Laboratories)

Sample Date	Analyte	Amount Detected (µg/L)	Test Method ^a	Laboratory
08-21-98	Acetone	3.7 J (5.0)	EPA 8260	GEL
08-21-98	2-Hexanone	7	EPA 8260	GEL
03-16-00	2-Hexanone	14 J (40)	EPA 8260	ERCL
03-16-00	4-methyl-2-Pentanone	8.2 J (20)	EPA 8260	ERCL

Note: Values in **bold** represent detected analytes.

^aEPA November 1986.

EPA = U.S. Environmental Protection Agency.

ERCL = Environmental Restoration Chemistry Laboratory.

GEL = General Engineering Laboratories.

J () = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

µg/L = Microgram(s) per liter.

SVOC = Semivolatile organic compound.

SWMU = Solid Waste Management Unit.

TAI = Technical Area I.

VOC = Volatile organic compound.

W = West.

Table 4.4.8-3
Summary of SWMU 190 Groundwater Sampling (Investigation #7)
VOC and SVOC Analytical Results—Detections Only
Monitoring Well TAI-W-07
(On- and Off-Site Laboratories)

Sample Date	Analyte	Amount Detected (µg/L)	Test Method ^a	Laboratory
12-16-98	1,1-Dichloroethene	0.53 J (2)	EPA 8260	ERCL
03-10-99	1,1-Dichloroethene	0.54 J (2)	EPA 8260	ERCL
07-21-99	1,1-Dichloroethene	0.59 J (2)	EPA 8260	ERCL
03-16-00	1,1-Dichloroethene	0.71 J (2)	EPA 8260	ERCL
10-04-01	1,1-Dichloroethene	1 J (2)	EPA 8260	ERCL
11-26-01	1,1-Dichloroethene	0.69 J (2)	EPA 8260	ERCL
07-21-99	Di-n-octyl phthalate	5.6 JH (10.2)	EPA 8270	GEL

Notes: Values in **bold** represent detected analytes.

^aEPA November 1986.

EPA = U.S. Environmental Protection Agency.

ERCL = Environmental Restoration Chemistry Laboratory.

GEL = General Engineering Laboratories.

H = Analysis performed beyond recommended holding time; reported concentration is an estimated value.

J () = The reported value is greater than or equal to the method detection limit but

is less than the practical quantitation limit, shown in parentheses

µg/L = Microgram(s) per liter.

SVOC = Semivolatile organic compound.

SWMU = Solid Waste Management Unit.

TAI = Technical Area I.

VOC = Volatile organic compound.

W = West.

Table 4.4.8-4
Summary of SWMU 190 Groundwater Sampling (Investigation #7)
VOC and SVOC Analytical Results—Detections Only
Monitoring Well TA2-NW1-325
(On- and Off-Site Laboratories)

Sample Date	Analyte	Amount Detected (µg/L)	Test Method ^a	Laboratory
03-26-93	Acetone	4.8 BJ (10)	EPA 8240	Enseco
07-18-94	Acetone	5 BJ (10)	EPA 8260	Encotec
07-18-94	Acetone	4 BJ (10)	EPA 8260	Encotec
01-25-96	Acetone	12 B	EPA 8260	Lockheed
07-18-94	Di-n-butyl phthalate	1 J (10)	EPA 8270	Encotec
07-18-94	Di-n-butyl phthalate	6 J (10)	EPA 8270	Encotec
03-26-93	Methylene chloride	1 J (5)	EPA 8240	Enseco
01-06-94	Methylene chloride	1 J (5)	EPA 8240	Encotec
07-18-94	Methylene chloride	5 B	EPA 8260	Encotec
07-18-94	Methylene chloride	6 B	EPA 8260	Encotec
10-13-94	Methylene chloride	2 B	EPA 8010	Encotec
01-25-96	Methylene chloride	0.22 J (5)	EPA 8260	Lockheed
09-26-97	Methylene chloride	0.5 J (2)	EPA 8260	ERCL
12-08-97	Methylene chloride	5.5	EPA 8260	GEL
04-21-00	Methylene chloride	4.2 B	EPA 8260	ERCL
01-11-01	Methylene chloride	0.88 J (2)	EPA 8260	ERCL
12-10-01	Tetrachloroethene	0.75 J (2)	EPA 8260	ERCL
10-13-94	Toluene	2	EPA 8020	Encotec
09-27-95	Trichloroethene	0.6	EPA 8010	Lockheed
01-25-96	Trichloroethene	1.2 J (2)	EPA 8260	ERCL
07-10-01	Trichloroethene	0.3 J (0.4)	EPA 8260	ERCL
10-02-01	Trichloroethene	0.31 J (0.4)	EPA 8260	ERCL
12-10-01	Trichloroethene	0.53	EPA 8260	ERCL
06-20-95	bis(2-Ethylhexyl)phthalate	13	EPA 8270	Lockheed
01-25-96	bis(2-Ethylhexyl)phthalate	7.1 J (10)	EPA 8270	Lockheed

Notes: Values in **bold** represent detected analytes.

^aEPA November 1986.

B = Analyte detected in an associated blank.

EPA = U.S. Environmental Protection Agency.

ERCL = Environmental Restoration Chemistry Laboratory.

GEL = General Engineering Laboratories.

J () = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses

µg/L = Microgram(s) per liter.

NW = Northwest.

SWMU = Solid Waste Management Unit.

SVOC = Semivolatile organic compound.

TA2 = Technical Area II.

VOC = Volatile organic compound.

4.5 Site Conceptual Model

The site conceptual model for SWMU 190 is based upon the COCs identified in surface and subsurface soil samples during the RFI, LIF/CPT, and the EC/VCM activities. The determination of the nature, migration rate, and extent of contamination at SWMU 190 was based upon a conceptual model refined by sampling. The initial conceptual model was developed from archival research, interviews with past site workers, review of aerial photographs, and soil sampling. The DQOs contained in the SWMU 190 RFI Work Plan identified the sample locations, sample density, sample depth, and analytical requirements. The sample data subsequently were used to develop the final conceptual model for SWMU 190. This section summarizes the nature and extent of contamination and the environmental fate of COCs.

4.5.1 Nature and Extent of Contamination

Both the nature of contamination and the potential for the degradation of COCs at SWMU 190 were evaluated using laboratory analyses of the soil samples for TPH, VOCs, and SVOCs. These analytes and methods, which are listed in the analytical result summary tables with this chapter, are appropriate for characterizing both the COCs and potential degradation products at SWMU 190.

SWMU 190 is predominantly an inactive site where all primary sources of COCs have been eliminated. As a result, only secondary sources of COCs potentially remain in the soil in the form of adsorbed COCs (TPH, VOCs, and SVOCs). The rate of COC migration from surficial soil is therefore predominantly dependent upon precipitation and occasional surface-water flow. Data available from sources, including the TAG Investigation, numerous SNL/NM monitoring programs for air and surface water, various biological surveys, and meteorological monitoring, are adequate for characterizing the rate of COC migration at SWMU 190.

Surface and subsurface soil samples were collected from the area around the known pipeline rupture in SWMU 190 to assess the effects on human health and the environment. For the RFI, soil samples were collected from the ground surface to a maximum depth of 111 feet bgs. The vertical rate of contamination migration was expected to be extremely low for SWMU 190 because of the low precipitation, high evapotranspiration, impermeable vadose zone soils, and the relatively low solubility of diesel fuel-oil components. Therefore, the soil samples are considered to be representative of the soil potentially contaminated with the COCs and adequate for determining the vertical extent of COCs. In summary, the design of the RFI sampling was appropriate and adequate to determine the nature, migration rate, and extent of residual COCs in soil at SWMU 190.

The COCs at SWMU 190 include TPH and associated VOCs and SVOCs related to the known pipeline rupture that leaked during an indeterminate length of time. All of these man-made compounds were considered to be COCs when concentrations exceeded the corresponding MDLs and were included in assessing the risk to human health and the environment.

The soil samples collected during numerous investigations at SWMU 190 are considered to be representative of the *in situ* soil potentially contaminated with TPH and adequate to determine the vertical extent of TPH, for the following reasons:

- The release caused by the known pipeline rupture introduced fuel oil into the near subsurface soils.
- No data or other information suggested that the fuel oil had been released to the environment anywhere else on the site.
- The vertical rate of contamination migration was expected to be extremely low for SWMU 190 because of the low precipitation, high evapotranspiration, impermeable vadose zone soil, and the relatively low solubility of fuel oil.

4.5.2 Environmental Fate

The primary release of COCs at SWMU 190 occurred to the near subsurface soil as a result of a leak in the underground piping. The pipeline rupture released TPH COCs to the underlying soil over time. Under the current conditions, wind, water, and biota are potential natural mechanisms for COC transport from the site.

The mobility and persistence of TPH at this site is well known. Because fuel oil is a relatively inert compound, dispersion and accumulation in the environment are important factors in the fate of TPH contamination. Generally, TPH can be transported in three phases at the surface: a dissolved phase, a pure oil phase, and an adsorbed phase (on sediments). With low water solubility and a high viscosity in the oil state, the adsorbed phase of TPH is the most important mechanism for migration. Consequently, these COCs have a low mobility at the site.

Fuel oil is a complex mixture of hydrocarbon compounds. Volatile constituents may evaporate or move through the soil in the vapor phase and are expected to move further from the release site than the larger, heavier hydrocarbon constituents. Heavier hydrocarbon compounds are not expected to migrate rapidly through the soil. Biodegradation of both light and heavy hydrocarbons may occur, but this is generally a slow process in arid regions (API September 1994, Mull 1971, Kostecke and Calabrese 1989a, 1989b).

Possible secondary release mechanisms include suspension and/or dissolution of trace levels of residual COCs in both surface-water runoff and percolation to the vadose zone, direct contact of receptors with soil, wind erosion/dust emissions, and uptake of COCs in the soil by biota. The depth to groundwater at the site (approximately 275 feet bgs) precludes migration of residual COCs into the shallow groundwater system. The pathways to receptors are soil ingestion, inhalation, and direct exposure. Plant uptake also was considered as a pathway for the residential scenario only. Annex 4-B provides additional discussion of the fate and transport of COCs at SWMU 190.

The current and future land use for SWMU 190 is industrial (DOE and USAF September 1995). However, because long-term stewardship issues have not been addressed, a residential land use scenario is also considered. For all applicable pathways, the exposure route for the receptor is dermal contact and ingestion/inhalation. Potential biota receptors include flora and fauna at the site. Similar to the human receptor, ingesting COCs through food chain transfers or

indirect uptakes are the major pathways. Annex 4-B provides additional discussion of the exposure routes and receptors at SWMU 190.

4.6 Site Assessments

Site assessments at SWMU 190 include risk screening assessments followed by risk baseline assessments (as required) for both human health and ecological risk. The following sections summarize the site assessment results. Annex 4-B provides details of the risk screening assessment.

4.6.1 Summary

The risk screening assessments conclude that SWMU 190 poses insignificant threat to human health under an industrial land use scenario. After considering the uncertainties associated with the available data and modeling assumptions, ecological risks associated with SWMU 190 were found to be acceptable. Section 4.6.2 briefly describes the screening assessments, which are detailed in Annex 4-B.

4.6.2 Screening Assessments

Risk screening assessments were performed for both human health risk and ecological risk for SWMU 190. This section briefly summarizes the risk screening assessments.

4.6.2.1 Human Health

SWMU 190 has been recommended for industrial land use (DOE and USAF September 1995). Annex 4-B provides a complete discussion of the risk assessment process, results, and uncertainties. Because COCs are present in concentrations greater than background levels at the site, it was necessary to perform a human health risk assessment analysis for SWMU 190. Generally, COCs evaluated in this risk assessment included all detected organic COCs for which samples were analyzed. The risk assessment process provides a quantitative evaluation of the potential adverse human health effects caused by constituents in the site's soil by calculating the hazard index (HI) and excess cancer risk for an industrial land use scenario.

In summary, the HI for an industrial land use scenario calculated for all COCs for SWMU 190 is 0.7, which is less than the numerical standard of 1.0 suggested by risk assessment guidance (EPA 1989). The excess cancer risk for COCs at SWMU 190 is $8E-6$ for an industrial land use scenario. NMED Guidance states that cumulative excess lifetime cancer risk must be less than $1E-05$ (Bearzi January 2001), thus the excess cancer risk for this site is less than the acceptable risk value for an industrial land use scenario.

4.6.2.2 Ecological

An ecological risk screening assessment that corresponds with the screening procedures in the EPA's Ecological Risk Assessment Guidance for Superfund (EPA 1997b) was performed as set forth by the NMED Risk-Based Decision Tree (NMED March 1998). An early step in the

evaluation compared COC concentrations to background screening values and identified potentially bioaccumulative constituents (Annex 4-B, Sections VII.2, and VII.3). This methodology also required developing a site conceptual model, and a food web model, as well as selecting ecological receptors. Each of these items was presented in the "Predictive Ecological Risk Assessment Methodology for SNL/NM ER Program, Sandia National Laboratories/New Mexico" (IT July 1998) and will not be duplicated here. The screening also included an estimation of exposure and ecological risk.

Table 11 of Annex 4-B presents the results of the ecological risk screening assessment. Site-specific information was incorporated into the screening assessment when such data were available. Several hazard quotients greater than 1 were originally predicted; however, closer examination of the exposure assumptions revealed an overestimation of risk primarily attributed to exposure concentrations (maximum COC concentrations detected in soil samples were used in estimating risk), the site habitat, the wildlife toxicity benchmarks, diet extremes for the deer mouse, the area use factor for wildlife receptors, and background risk. Based upon an evaluation of these uncertainties, ecological risks associated with this site are expected to be very low.

4.6.3 Baseline Risk Assessments

This section discusses the baseline risk assessments for human health and ecological risk.

4.6.3.1 *Human Health*

Because results of the human health risk screening assessment summarized in Section 4.6.2.1 indicate that SWMU 190 does not demonstrate the potential to affect human health under an industrial land use scenario, a baseline human health risk assessment is not required for the site.

4.6.3.2 *Ecological*

The results of the ecological screening assessment summarized in Section 4.6.2.2 indicate that SWMU 190 poses very low ecological risk. Therefore, a baseline ecological risk assessment is not required for the site.

4.6.4 Other Applicable Assessments

Surface-Water Assessment

A surface-water site assessment was conducted at SWMU 190 in June 2001 (Annex 4-C) (SNL/NM June 2001), in accordance with guidance developed jointly by Los Alamos National Laboratory and the NMED Surface-Water Quality Bureau to evaluate the potential for erosion from SWMU 190. SWMU 190 received a score of 60.3, indicating high erosion potential, primarily due to run-on from an asphalt-covered parking lot northeast of the site. The parking lot forms an arroyo that flows just east of the area of the known fuel-oil contamination. The site was graded after the excavation in the area of the pipeline rupture was backfilled, and the

drainage area was re-directed around the contaminated soil to reduce future erosion potential at the site. As discussed in Section 4.5, the COCs detected at the site were present at greater depths indicating that surface-water runoff is not causing migration of highly contaminated soil. In addition, as discussed in the Results and Conclusions sections for each of the investigations and the Screening Assessments (Section 4.6.2), COCs were not detected at levels that could either pose a threat to human health or the environment, or adversely affect surface-water quality.

4.7 No Further Action Proposal

4.7.1 Rationale

Based upon field investigation data and the human health and ecological risk screening assessment analyses, an NFA decision is recommended for SWMU 190 because no COCs were present in concentrations considered hazardous to human health for an industrial land use scenario.

4.7.2 Criterion

Based upon the evidence provided above, SWMU 190 is proposed for an NFA decision in conformance with Criterion 5 (NMED March 1998), which states, "The SWMU/AOC has been characterized or remediated in accordance with current applicable state or federal regulations, and that available data indicate that contaminants pose an acceptable level of risk under current and projected future land use."

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ANNEX 4-B
Risk Screening Assessment

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SWMU 190: RISK SCREENING ASSESSMENT REPORT**I. Site Description and History**

Solid Waste Management Unit (SWMU) 190, the Steam Plant Tank Farm at Sandia National Laboratories/New Mexico (SNL/NM), encompasses three acres in the southwest portion of Technical Area (TA)-I, near the intersection of Wyoming Boulevard and Hardin Boulevard. This land is owned by Kirtland Air Force Base (KAFB) and leased to the U.S. Department of Energy.

Environmental concern about SWMU 190 is based upon a leak in a diesel fuel distribution line detected in 1991. Numerous investigations of soil contamination have been conducted at the site since the discovery of the leak. A minor investigation was conducted before the TA-I Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was initiated in 1995. In 1998, a Voluntary Corrective Measure (VCM) was initiated at SWMU 190 to aid in biological remediation of diesel-fuel-contaminated soils at the site. Although the concentrations of diesel fuel components did not represent a human health risk, the VCM was implemented by SNL as a best-management practice.

The natural ground surface at the site is nearly level, with a gradual slope of 1 to 2 percent to the south. Man-made secondary containment berms with a local relief of 5 to 8 feet were constructed around each of the five aboveground tanks within SWMU 190. Elevations from north to south across the main portion of the site vary from 5,401 to 5,396 feet above mean sea level, for a total natural relief across the site of 5 feet. There is a surface-water channel that cuts across the site from northeast to southwest and becomes part of the TA-I storm water system just outside the southwest corner of the site. A major drainage feature in the vicinity of the site is the Tijeras Arroyo, which is located approximately 0.75 miles southeast of the site. Surface runoff is collected in a combined aboveground and underground storm drain system that discharges adjacent to TA-IV into Tijeras Arroyo. The arroyo originates in Tijeras Canyon, which is bounded by the Sandia Mountains to the north and the Manzano Mountains to the south. The arroyo trends southwest to west, eventually draining into the Rio Grande, approximately 8 miles west of SWMU 190.

SWMU 190 rests on a partially dissected bajada formed by multiple, coalescing alluvial fan complexes that originate in the mountain ranges to the east. The Holocene and Pleistocene deposits on the surface are comprised of alluvial fan deposits shed from the eastern uplifts that interfinger with valley alluvium west of the site. The thickness of these Holocene and Pleistocene deposits is thought to be less than 10 feet. Surficial deposits derived from the Tijeras Arroyo drainage contain granitic and sedimentary lithologies from the Sandia Mountains as well as sedimentary and metamorphic lithologies from the Manzanita Mountains. The surficial deposits are underlain by the upper unit of the Tertiary Santa Fe Group (Connell et al. 1999), which consists of coarse- to fine-grained alluvial fan/piedmont veneer facies that extend westward from the Sandia and Manzanita Mountains. The upper Santa Fe Group unit is approximately 1,200 feet thick in the vicinity of the site.

The soil at the site is part of the Embudo-Tijeras complex, which consists of deep, well-drained, moderately alkaline soil (pH of 7.9 to 8.4) that formed in decomposed granitic alluvium on old alluvial fans. Permeability of this soil is moderate (0.6 to 2.0 inches/hour).

Groundwater monitoring for the area surrounding SWMU 190 is conducted as part of the Tijeras Arroyo (formerly Sandia North) Groundwater Investigation. Two water-bearing zones, the shallow groundwater system and the regional aquifer, underlie SWMU 190. Two monitoring wells (TAI-W-01 and TAI-W-07, deep and shallow wells, respectively) are located within the boundaries of SWMU 190. The shallow groundwater system is not used for water supply purposes. The depth to the shallow groundwater system is approximately 275 feet below ground surface (bgs) and the depth to the regional aquifer is approximately 535 feet bgs. Both the City of Albuquerque and KAFB use the regional aquifer as a water supply, and the pumping of city wells has created a cone of depression in the northern portion of SNL/NM that affects groundwater flow in the vicinity of the site. The nearest water-supply well is KAFB-1 located approximately 1/2 mile northwest of the site.

The climatic conditions are those normally associated with the high desert plateau: low precipitation, sunny days, and wide temperature ranges. Precipitation for the SNL/NM-KAFB area averages 10 to 12 inches per year. The weather is typically sunny and clear, with an average of 169 sunny days per year. The average diurnal temperature range is 28 degrees Fahrenheit (°F). Daily low temperatures during the winter normally fall within 23 to 27°F, and high normal temperatures during the summer months range from 82 to 91°F. Winds are typically out of the east with an average speed of 9 miles per hour. Evapotranspiration has been estimated at 95 percent of the annual rainfall.

The site has been heavily disturbed by human activity for more than 50 years, and at the present time no plants are allowed to grow within the site boundaries. Generally, the diversity and abundance of animal species in areas in and around TA-I varies at given locations, depending upon the quantity and quality of necessary habitat. Given the amount of known human intrusion at the site, a great diversity or abundance of animal species is unlikely, although the site-specific species have not been quantified. No suitable habitat remains within the site boundaries to sustain a viable ecological system.

Natural areas outside the site boundaries are dominated by grassland vegetation; black grama, blue grama, and western cheatgrass comprise 30 to 40 percent of the vegetative mass. Indigenous wildlife includes amphibians, reptiles, birds, and small mammals. Thirteen species of concern have been identified at SNL/NM-KAFB locations. Within TA-I, however, neither threatened or endangered species nor species of concern have been identified. There are no permanent wetlands identified in TA-I.

II. Data Quality Objectives

II.1 RFI—Characterization Sampling

The Data Quality Objectives (DQOs) presented in both the TA-I RFI Plan and subsequent field sampling plans for SWMU 190 identified the site-specific characterization sample locations, sample depths, sampling procedures, and analytical requirements. The DQOs outlined the Quality Assurance (QA)/Quality Control (QC) requirements necessary for producing defensible analytical data suitable for risk assessment purposes. The characterization sampling conducted at SWMU 190 was designed to:

- Determine whether diesel fuel components occur in surface and shallow subsurface soil at concentrations detectable by a field test kit.
- Characterize the nature and extent of any constituents of concern (COCs) by laboratory analysis of composite and discrete surface and shallow subsurface soil samples.
- Provide analytical data of sufficient quality to support risk screening assessments.

Characterization samples were collected at 48 locations across SWMU 190, using the sampling procedures detailed in both the TA-I Work Plan and subsequent field sampling plans. The sample numbers, sample dates, and chain-of-custody form numbers are identified in the data tables presented in the associated No Further Action (NFA) proposal. Using a hand auger or geoprobe, surface soil samples were collected from a depth of 0 to 2 feet bgs; and subsurface samples to a maximum depth of 111 feet bgs.

The SWMU 190 characterization samples were analyzed for all COCs: total petroleum hydrocarbons (TPH) (by immunoassay), TPH (by multiple U.S. Environmental Protection Agency [EPA] Methods), volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs) (Table 1). The samples were analyzed by General Engineering Laboratories and the on-site SNL/NM Environmental Restoration (ER) Chemistry Laboratory.

Table 2 summarizes the analytical methods and the data quality level requirements from the TA-I RFI Work Plan.

QA/QC samples were collected during the characterization sampling effort according to the ER Project Quality Assurance Project Plan (QAPP). The QA/QC samples consisted of duplicates, trip blanks, field blanks, and equipment blanks. Duplicate soil samples were collected at 5 percent of the sampling locations. Equipment-wash (aqueous rinsate) blanks were prepared after sampling and decontamination of sampling tools. Field blanks were collected by exposing a jar of clean soil to atmospheric conditions in the work area. Trip blanks accompanied the soil samples requiring VOC analyses. No significant QA/QC problems were identified in the QA/QC samples.

A portion of the characterization sampling results were verified/validated by SNL/NM. The off-site laboratory results were reviewed using procedures similar to those described in "Data Validation Procedure for Chemical and Radiochemical Data, SNL/NM Environmental Restoration Project Analytical Operating Procedure (AOP) 00-03, Rev. 0" (SNL/NM January 2000). The reviews confirmed that the analytical data from the analytical laboratories are defensible and therefore acceptable for use in the NFA proposal. Therefore, the DQOs have been fulfilled.

Table 1
Number of Characterization Soil Samples Collected During the SWMU 190 RFI

Sample Type	TPH (Immunoassay)	TPH (EPA Methods)	TPH (EPA Methods)	VOCs	VOCs	SVOCs
Surface Soils (0-2 ft)	40	26	2	26	2	NA
Subsurface Soils (to 111 ft)	174	117	28	117	28	5
Duplicates	NA	NA	2	NA	2	NA
VOC Trip Blanks	NA	NA	NA	NA	10	NA
VOC Field Blanks	NA	NA	NA	NA	2	NA
Equipment Blanks	NA	NA	3	NA	3	1
Total Samples	214	143	35	143	47	6
Analytical laboratory	ERCL/ERFO	ERCL	GEL	ERCL	GEL	GEL

Sampling dates: May 1995 through November 1996.

Analysis request/chain-of-custody records: 03394, 03395, 03396, 03397, 03398, 03399, 03400, 03402, 03508, 03509, 03510, 03511, 05130, 05573, 05574, 05575, and 05710.

EPA = U.S. Environmental Protection Agency.

ERCL = Environmental Restoration Chemistry Laboratory.

ERFO = Environmental Restoration Field Office.

ft = Foot (feet).

GEL = General Engineering Laboratories, Inc.

NA = Not applicable.

RCRA = Resource Conservation and Recovery Act.

RFI = RCRA Facility Investigation.

SVOC = Semivolatile organic compound.

SWMU = Solid Waste Management Unit.

TPH = Total petroleum hydrocarbon.

VOC = Volatile organic compound.

Table 2
Summary of Data Quality Requirements

Analytical Requirement	Data Quality Level	GEL (Off Site)	ERCL (On Site)
TPH Immunoassay	Screening	not analyzed	214
TPH EPA Method 8015	Defensible	35	143
VOCs EPA Method 8260	Defensible	47	143
SVOCs EPA Method 8270	Defensible	6	not analyzed

The number of samples includes QA/QC samples, such as duplicates, trip blanks, and equipment blanks.

EPA = U.S. Environmental Protection Agency.

ERCL = Environmental Restoration Chemistry Laboratory.

GEL = General Engineering Laboratories, Inc.

QA = Quality assurance.

QC = Quality control.

SVOC = Semivolatile organic compound.

TPH = Total petroleum hydrocarbon.

VOC = Volatile organic compound.

III. Determination of Nature, Rate, and Extent of Contamination

III.1 Introduction

The determination of the nature, migration rate, and extent of contamination at SWMU 190 was based upon a conceptual model refined by RFI sampling. The initial conceptual model was developed from archival research, interviews with past site workers, aerial photographs, and soil sampling. The DQOs contained in the SWMU 190 RFI Work Plan identified the sample locations, sample density, sample depth, and analytical requirements. The sample data were subsequently used to develop the final conceptual model for SWMU 190, which is presented in Section 2.5 of the associated NFA proposal. The quality of the data used specifically to determine the nature, migration rate, and extent of contamination are described below.

III.2 Nature of Contamination

Both the nature of contamination and the potential for the degradation of COCs at SWMU 190 were evaluated using laboratory analyses of the soil samples. For the RFI, the analytical requirements included analyses for TPH, VOCs, and SVOCs. The analytes and methods listed in Tables 1 through 3 are appropriate to characterize both the COCs and any potential degradation products at SWMU 190.

III.3 Rate of Contaminant Migration

SWMU 190 is an inactive site where all primary sources of COCs have been eliminated. As a result, only secondary sources of COCs potentially remain in soil in the form of adsorbed COCs (TPH, VOCs, and SVOCs). The rate of COC migration from surficial soil is therefore predominantly dependent upon precipitation and occasional surface-water flow. Data available from sources, including the Tijeras Arroyo Groundwater Investigation, numerous SNL/NM monitoring programs for air and surface water, various biological surveys, and meteorological monitoring, are adequate to characterize the rate of COC migration at SWMU 190.

III.4 Extent of Contamination

Surface and subsurface soil samples were collected from the area around the leaking pipeline at SWMU 190 to assess the effects on human health and the environment. For the RFI, soil samples were collected from the ground surface to a maximum depth of 111 feet bgs. The vertical rate of contamination migration was expected to be extremely low for SWMU 190 because of the low precipitation, high evapotranspiration, impermeable vadose zone soils, and the relatively low solubility of diesel fuel components. Therefore, the soil samples are considered to be representative of the soil potentially contaminated with the COCs and sufficient to determine the vertical extent of COCs. In summary, the design of the RFI sampling was appropriate and adequate to determine the nature, migration rate, and extent of residual COCs in soils at SWMU 190.

IV. Comparison of COCs to Background Screening Levels

Site history and characterization activities are used to identify potential COCs. The SWMU 190 NFA proposal describes the identification of COCs and the sampling that was conducted in order to determine the concentration levels of those COCs across the site. Generally, COCs evaluated in this risk assessment include all detected organic compounds. When the detection limit of an organic compound was too high (i.e., could possibly cause an adverse effect to human health or the environment), the compound was retained. Nondetected organic compounds not included in this assessment were found to have detection limits low enough to ensure protection of human health and the environment.

In many locations, TPH, VOC and SVOC samples were collected concurrently. However, the maximum concentration of TPH in the interval from 0 to 5 feet had only an associated VOC sample (no SVOC sample). The maximum TPH concentration from 0 to total investigation depth had neither associated VOC nor SVOC sample results. The COCs for diesel #2 were determined (NMED March 2000) and concentrations of these COCs were conservatively derived from the maximum TPH concentration (0 to total depth) (Potter and Simmons 1998) (Appendix 1) for both the human health and ecological risk screening assessments. The 0 to 5 feet maximum concentration (49,000 J milligrams [mg]/kilogram [kg]) was not used in the risk analysis because it represents very localized (<1 cubic foot) contamination below a dripping valve.

Only the maximum TPH concentration value found for the 0 to total depth of investigation was used in the calculation in order to provide conservatism in this risk assessment. Because all constituents were organic compounds, no calculated background constituents exist (Dinwiddie September 1997). Therefore, a comparison to background was not performed. Human health

nonradiological COCs were compared to SNL/NM proposed Subpart S action levels if applicable (Table 3) (IT July 1994).

Table 3 lists the COCs for the human health and ecological risk assessment at SWMU 190. Table 3 is discussed in Sections VI.4, VII.2 and VII.3.

V. Fate and Transport

The primary releases of COCs at SWMU 190 were to the surface soil as a result of diesel pipeline leaks at the Steam Plant Tank Farm. Wind, water, and biota are natural mechanisms of COC transport from the primary release point. Because of the open soil surface at this site, wind may be a potentially significant transport mechanism for COCs in the surface soil; however, winds near the soil surface may be moderated by the presence of the tanks and by the earth berms that surround the tanks.

Water at SWMU 190 is received as precipitation (rain and occasionally snow). As described in Section I, the site receives approximately 10 to 12 inches of precipitation per year. Because the tanks are surrounded by earth berms to provide secondary containment, some surface water also could be contained on the site; however, a surface channel crosses the site that could collect surface-water runoff from unbermed areas of the site. This surface-water flow could carry COCs off site, and potentially to the Tijeras Arroyo. Surface water that remains on site will either evaporate or infiltrate into the soil. Water that infiltrates into the soil can potentially leach COCs deeper into the subsurface soil as it percolates downward. Evapotranspiration rates are high, however, with average losses of approximately 95 percent of precipitation. Because of the low annual precipitation, high evapotranspiration rates, and depth to groundwater at this site (approximately 275 feet bgs), infiltration and percolation are not considered to be potential mechanisms to carry COCs into the groundwater.

COCs in the soil can enter the food chain via uptake by plant roots. Because the habitat at SWMU 190 (originally grassland) has been highly disturbed and modified by the construction of the tank farm, plant growth is controlled and few ecological receptors inhabit or use the site. Therefore, food chain uptake is not considered to be a potentially significant transport mechanism at this site.

The COCs at SWMU 190 are limited to organic compounds associated with petroleum fuels. Organic COCs may be degraded through photolysis, hydrolysis, and biotransformation. Photolysis requires light, and therefore takes place in the air, at the ground surface, or in surface water. Hydrolysis includes chemical transformations in water, and may occur in the soil solution. Biotransformation (i.e., transformation due to plants, animals, and microorganisms) may occur; however, biological activity may be limited by the aridity of the environment at this site. Some organic COCs (e.g., benzene, toluene, and xylenes) may be lost through volatilization.

Table 4 summarizes the fate and transport processes that may occur at SWMU 190. Because the soil surface is generally open, wind may be of moderate significance as a transport mechanism. Surface water from unbermed parts of the site may be a transport mechanism for COCs in soil. Because of the low precipitation rates and high evapotranspiration rates of this area, leaching of COCs into groundwater is not expected to occur. Although the site is open to

Table 3
Nonradiological COCs for Human Health and Ecological Risk Assessments at
SWMU 190 with Comparison to the Associated BCF, and Log K_{ow}

COC Name	Maximum Concentration (mg/kg)	BCF (maximum aquatic)	Log K_{ow} (for organic COCs)	Bioaccumulator?^a (BCF>40, log K_{ow}>4)
Acenaphthene	741	389 ^b	3.92 ^b	Yes
Anthracene	2.3	917 ^c	4.45 ^c	Yes
Benzene	11.3	5.2 ^c	2.13 ^c	No
Benzo(a)anthracene	0.037	10,000 ^b	5.61 ^b	Yes
Benzo(a)pyrene	0.086	3,000 ^c	6.04 ^c	Yes
Benzo(b)fluoranthene	0.012	—	6.124 ^b	Yes
Benzo(k)fluoranthene	0.012	93,325 ^b	6.84 ^b	Yes
Chrysene	0.018	18,000 ^b	5.91 ^b	Yes
Ethylbenzene	26.5	15.5 ^d	3.15 ^d	No
Fluoranthene	2.3	12,302 ^b	4.90 ^b	Yes
Fluorene	218	2,239 ^b	4.18 ^b	Yes
Naphthalene	1209	1,000 ^b	3.30 ^b	Yes
Phenanthrene	34.3	23,800 ^c	4.63 ^c	Yes
Pyrene	1.8	36,300 ^c	5.32 ^b	Yes
Toluene	70.2	10.7 ^c	2.69 ^c	No
Xylene, mixture	195	23.4 ^e	1.5 ^b	No

Note: **Bold** indicates the COCs that are bioaccumulators.

^aNMED (March 1998).

^bMicromedex (1998)

^cYanicak (March 1997).

^dHoward (1989)

^eHoward (1990)

BCF = Bioconcentration factor.

COC = Constituent of concern.

K_{ow} = Octanol-water partition coefficient.

Log = Logarithm (base 10).

mg/kg = Milligram(s) per kilogram.

NMED = New Mexico Environment Department.

SWMU = Solid Waste Management Unit.

— = Information not available.

Table 4
Summary of Fate and Transport at SWMU 190

Transport and Fate Mechanism	Existence at Site	Significance
Wind	Yes	Moderate
Surface runoff	Yes	Moderate
Migration to groundwater	No	None
Food chain uptake	Yes	Very low
Transformation/degradation	Yes	Moderate

SWMU = Solid Waste Management Unit.

use by wildlife, the lack of vegetation on the site makes uptake of COCs into the food chain an insignificant transport mechanism for COCs. Because of the organic nature of the COCs, degradation and/or transformation may be of moderate importance at this site, and some COCs may be lost near the soil surface through volatilization.

VI. Human Health Risk Screening Assessment

VI.1 Introduction

Human health risk screening assessment of this site includes a number of steps that culminate in a quantitative evaluation of the potential adverse human health effects caused by COCs located at the site. The steps to be discussed include the following:

Step 1.	Site data are described that provide information on the potential COCs, as well as the relevant physical characteristics and properties of the site.
Step 2.	Potential pathways are identified by which a representative population might be exposed to the COCs.
Step 3.	The potential intake of these COCs by the representative population is calculated using a tiered approach. The first component of the tiered approach includes two screening procedures. One screening procedure compares the maximum concentration of the COC to an SNL/NM maximum background screening value. COCs that are not eliminated during the first screening procedure are subjected to a second screening procedure that compares the maximum concentration of the COC to the SNL/NM proposed Subpart S action level.
Step 4.	Toxicological parameters are identified and referenced for COCs that were not eliminated during the screening steps.
Step 5.	Potential toxicity effects (specified as a hazard index [HI]) and estimated excess cancer risks are calculated for COCs and background risk.
Step 6.	These values are compared with guidelines established by the EPA and the New Mexico Environment Department (NMED) to determine whether further evaluation and potential site cleanup are required. COC risk values also are compared to background risk so that an incremental risk can be calculated.
Step 7.	Uncertainties regarding the contents of the previous steps are addressed.

VI.2 Step 1. Site Data

Section I of this Risk Screening Assessment provides the site description and history for SWMU 190. Section II presents the argument that the DQOs were satisfied. Section III describes the determination of the nature, rate, and extent of contamination.

VI.3 Step 2. Pathway Identification

SWMU 190 has been designated with a future land use scenario of industrial (DOE et al September 1995) (see Appendix 2 for default exposure pathways and parameters). Because of the location and characteristics of the potential contaminants, the primary pathway for human exposure to the COCs is considered to be soil ingestion. The inhalation pathway for the COCs is included because the potential exists to inhale dust and volatiles. No water pathways to the groundwater are considered. Depth to groundwater within the shallow water-bearing zone at SWMU 190 is approximately 275 feet bgs. The regional aquifer is approximately 540 feet bgs at this location. Because of the lack of surface water or other significant mechanisms for dermal contact, the dermal exposure pathway is not considered significant. No intake routes through plant, meat, or milk ingestion are considered appropriate for the industrial land use scenario. However, plant uptake is considered for the residential land use scenario.

Pathway Identification

Nonradiological Constituents
Soil ingestion
Inhalation (dust and volatiles)
Plant uptake (residential only)

VI.4 Step 3. COC Screening Procedures

This section discusses Step 3, which includes the two screening procedures. The first screening procedure compared the maximum COC concentration to the background screening level. The second screening procedure compared maximum COC concentrations to SNL/NM proposed Subpart S action levels. This second procedure was applied only to COCs not eliminated during the first screening procedure.

VI.4.1 Background Screening Procedure

VI.4.1.1 Methodology

Maximum concentrations of COCs were compared to the approved SNL/NM maximum screening levels for this area (Dinwiddie September 1997). Only the COCs either detected above their respective SNL/NM maximum background screening levels or without either a quantifiable or calculated background screening level were considered in further risk assessment analyses.

VI.4.1.2 *Results*

Table 3 presents SWMU 190 maximum COC concentrations. All sixteen COCs are organic compounds and therefore do not have corresponding calculated background concentrations.

VI.4.2 Subpart S Screening Procedure

VI.4.2.1 *Methodology*

The maximum concentrations of COCs not eliminated during the background screening process were compared, when applicable, with action levels (IT July 1994) calculated using methods and equations promulgated in the proposed RCRA Subpart S (EPA 1990) and Risk Assessment Guidance for Superfund (RAGS) (EPA 1989a) documentation. Accordingly, all calculations were based upon the assumption that receptor doses from both toxic and potentially carcinogenic compounds result most significantly from ingestion of contaminated soil. Because all of the samples were taken from the surface and near-surface soil, this assumption is considered valid. If there were ten or fewer COCs, and each had a maximum concentration of less than 1/10 the action level, then the site was judged to pose no significant health hazard to humans. If there were more than ten COCs, then the Subpart S screening procedure was not performed.

VI.4.2.2 *Results*

Results presented in Table 3 indicate that more than ten COCs failed the background screening procedure. Therefore, the Subpart S screening procedure was not performed. Thus, all COCs that exceeded the background screening values were carried forward in the risk assessment process, and an individual hazard quotient (HQ), cumulative HI, and excess cancer risk value were calculated for each COC.

VI.5 Step 4. Identification of Toxicological Parameters

Table 5 lists the COCs retained in the risk assessment and the values for the available toxicological information. The toxicological values used for nonradiological COCs in Table 5 were from the Integrated Risk Information System (IRIS) (EPA 1998a) and the Region 9 (EPA 1996) electronic databases.

VI.6 Step 5. Exposure Assessment and Risk Characterization

Section VI.6.1 describes the exposure assessment for this risk assessment. Section VI.6.2 provides the risk characterization, including the HI and the excess cancer risk for the COCs for both industrial and residential land uses.

Table 5
Toxicological Parameter Values for SWMU 190 Nonradiological COCs

COC Name	RfD _o (mg/kg-d)	Confidence ^a	RfD _{inh} (mg/kg-d)	Confidence ^a	SF _o (mg/kg-day) ⁻¹	SF _{inh} (mg/kg-day) ⁻¹	Cancer Class ^b
Acenaphthene	6E-2 ^c	L	6E-2 ^d	—	—	—	—
Anthracene	3E-1 ^c	L	3E-1 ^d	—	—	—	D
Benzene	1.7E-3 ^d	—	1.7E-3 ^d	—	2.9E-2 ^c	2.9E-2 ^c	A
Benzo(a)anthracene	—	—	—	—	7.3E-1 ^d	7.3E-1 ^d	—
Benzo(a)pyrene	—	—	—	—	7.3E+0 ^c	7.3E+0 ^d	B2
Benzo(b)fluoranthene	—	—	—	—	7.3E-1 ^d	7.3E-1 ^d	B2
Benzo(k)fluoranthene	—	—	—	—	7.3E-2 ^d	7.3E-2 ^d	B2
Chrysene	—	—	—	—	7.3E-3 ^d	7.3E-3 ^d	B2
Ethylbenzene	1E-1 ^c	L	2.9E-1 ^c	L	—	—	D
Fluoranthene	4E-2 ^c	L	4E-2 ^d	—	—	—	D
Fluorene	4E-2 ^c	L	4E-2 ^d	—	—	—	D
Naphthalene	4E-2 ^d	—	4E-2 ^d	—	—	—	D
Phenanthrene ^e	3E-1 ^c	L	3E-1 ^d	—	—	—	D
Pyrene	3E-2 ^c	L	3E-2 ^d	—	—	—	D
Toluene	2E-1 ^c	M	1.1E-1 ^c	M	—	—	D
Xylene, mixture	2E+0 ^c	M	2E-1 ^d	—	—	—	D

^aConfidence associated with IRIS (EPA 1998a) database values. Confidence: L = low, M = medium.

^bEPA weight-of-evidence classification system for carcinogenicity taken from IRIS (EPA 1998a):

A = Human carcinogen.

B2 = Probable human carcinogen. Sufficient evidence in animals and inadequate or no evidence in humans.

D = Not classifiable as to human carcinogenicity.

^cToxicological parameter values from IRIS electronic database (EPA 1998a).

^dToxicological parameter values from EPA Region 9 electronic database (EPA 1996).

^ePhenanthrene does not have toxicological parameter values. Anthracene used as surrogate.

COC = Constituent of concern. (mg/kg-day)⁻¹ = Per milligram per kilogram day.
EPA = U.S. Environmental Protection Agency. RfD_{inh} = Inhalation chronic reference dose.
IRIS = Integrated Risk Information System. RfD_o = Oral chronic reference dose.
mg/kg-d = Milligram(s) per kilogram day. SF_{inh} = Inhalation slope factor.

SF_o = Oral slope factor.

SWMU = Solid Waste Management Unit.

— = Information not available.

VI.6.1 Exposure Assessment

Appendix 2 provides the equations and parameter input values used in calculating intake values and subsequent HI and excess cancer risk values for the individual exposure pathways. The appendix shows parameters for both industrial and residential land use scenarios. The equations for the COCs are based upon the RAGS (EPA 1989a). Parameters are based upon information from the RAGS (EPA 1989a), as well as other EPA guidance documents, and reflect the reasonable maximum exposure (RME) approach advocated by the RAGS (EPA 1989a).

Although the designated land use scenario is industrial for this site, risk values for a residential land use scenario also are presented only to provide perspective of potential risk to human health under the more restrictive land use scenario.

VI.6.2 Risk Characterization

Table 6 shows an HI of 0.7 for the SWMU 190 COCs and an estimated excess cancer risk of $8\text{E-}6$ for the designated industrial land use scenario. The numbers presented include exposure from soil ingestion as well as inhalation of dust and volatiles for nonradiological COCs.

For nonradiological COCs in the residential land use scenario, the HI was 13 and the excess cancer risk was $1\text{E-}4$ (Table 6). The numbers in the table include exposure from soil ingestion, dust and volatile inhalation, and plant uptake. Although the EPA (EPA 1991) generally recommends that inhalation not be included in a residential land use scenario, this pathway was included because of the potential for soil in Albuquerque, New Mexico, to be eroded and, subsequently, for dust to be present in predominantly residential areas. Because of the nature of the local soil, other exposure pathways were not considered (see Appendix 2).

VI.7 Step 6. Comparison of Risk Values to Numerical Guidelines

The human health risk assessment analysis evaluated the potential for adverse health effects for both the industrial land use scenario (the designated land use scenario for this site) and the residential land use scenario.

For nonradiological COCs in the industrial land use scenario, the HI was 0.7 (less than the numerical guideline of 1 suggested in the RAGS [EPA 1989a]) (Table 6). Excess cancer risk was estimated at $8\text{E-}6$. NMED Guidance states that cumulative excess lifetime cancer risk must be less than $1\text{E-}5$ (Bearzi January 2001); thus, the excess cancer risk for this site is below the suggested acceptable risk value.

The calculated HI for the residential land use scenario nonradiological COCs was 13, which is above the numerical guidance (Table 6). Excess cancer risk was estimated at $1\text{E-}4$. NMED Guidance states that cumulative excess lifetime cancer risk must be less than $1\text{E-}5$ (Bearzi January 2001); thus, the excess cancer risk for this site is also above the suggested acceptable risk value.

Table 6
Risk Assessment Values for SWMU 190 Nonradiological COCs

COC Name	Maximum Concentration (mg/kg)	Industrial Land Use Scenario ^a		Residential Land Use Scenario ^a	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Acenaphthene	741	0.02	—	0.84	—
Anthracene	2.3	0.00	—	0.00	—
Benzene	11.3	0.46	8E-6	5.86	1E-4
Benzo(a)anthracene	0.037	0.00	1E-8	0.00	1E-7
Benzo(a)pyrene	0.086	0.00	2E-7	0.00	2E-6
Benzo(b)fluoranthene	0.012	0.00	3E-9	0.00	3E-8
Benzo(k)fluoranthene	0.012	0.00	3E-10	0.00	3E-9
Chrysene	0.018	0.00	5E-11	0.00	6E-10
Ethylbenzene	26.5	0.00	—	0.06	—
Fluoranthene	2.3	0.00	—	0.00	—
Fluorene	218	0.01	—	0.29	—
Naphthalene	1209	0.11	—	5.53	—
Phenanthrene	34.3	0.00	—	0.00	—
Pyrene	1.8	0.00	—	0.00	—
Toluene	70.2	0.03	—	0.16	—
Xylene, mixture	195	0.03	—	0.06	—
Total		0.7	8E-6	13	1E-4

^aFrom EPA (1989a).

COC = Constituent of concern.

EPA = U.S. Environmental Protection Agency.

mg/kg = Milligram(s) per kilogram.

SWMU = Solid Waste Management Unit.

— = Information not available.

VI.8 Step 7. Uncertainty Discussion

The determination of the nature, rate, and extent of contamination at SWMU 190 was based upon an initial conceptual model that was validated with sampling conducted across the site. The sampling was implemented in accordance with the SWMU 190 RFI Work Plan (SNL/NM February 1995). The DQOs contained in the Work Plan are appropriate for use in risk screening assessments. The data collected, based upon sample location, density, and depth, are representative of the site. The analytical requirements and results satisfy the DQOs. Therefore, there is no uncertainty associated with the data quality used to perform the risk screening assessment at SWMU 190.

Because of the location, history of the site, and future land use (DOE et al September 1995), there is low uncertainty in the land use scenario and the potentially affected populations that were considered in performing the risk assessment analysis. Because the COCs are found in surface and near-surface soils, and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values. This means that the parameter values in the calculations were conservative and calculated intakes were probably

overestimates. In many locations, TPH, VOC and SVOC samples were collected concurrently. However, the maximum concentration of TPH in the interval from 0 to 5 feet had only an associated VOC sample. The maximum TPH concentration from 0 to total investigation depth had neither associated VOC nor SVOC sample results. The COCs for diesel #2 were determined (NMED March 2000) and concentrations of these COCs were conservatively derived from the maximum TPH concentration (Potter and Simmons 1998) (Appendix 1) for both the human health and ecological risk screening assessments. The conversion of TPH to diesel #2 COCs was also considered to be very conservative. Diesel #2 was introduced into the environment in 1991. Benzene, which is the main risk driver, most likely would be almost completely removed from the environment by now. However, the TPH to diesel #2 COCs conversion assumes that the contamination occurred recently and that the diesel #2 is fresh.

Table 5 shows the uncertainties (confidence level) in the toxicological parameter values. There is a mixture of estimated values and values from the IRIS (EPA 1998a) and the EPA Region 9 (EPA 1996) electronic databases. Where values are not provided, information is not available from the Health Effects Assessment Summary Tables (HEAST) (EPA 1997a), IRIS (EPA 1998a), or the EPA regions (EPA 1996, 1997b). Because of the conservative nature of the RME approach, uncertainties in toxicological values are not expected to change the conclusion from the risk assessment analysis.

Both the human health HI and excess cancer risk for the nonradiological COCs were acceptable compared to established numerical guidance considering the industrial land use scenario.

The overall uncertainty in all of the steps in the risk assessment process is not considered to be significant with respect to the conclusion reached.

VI.9 Summary

SWMU 190 had identified COCs consisting of organic compounds. Because of the location of the site, the designated industrial land use scenario, and the nature of contamination, potential exposure pathways identified for this site included soil ingestion and dust and volatile inhalation. Plant uptake was included as an exposure pathway for the residential land use scenario.

Using conservative assumptions and an RME approach to risk assessment, calculations for nonradiological COCs show that for the industrial land use scenario the HI (0.7) was less than the accepted numerical guidance from the EPA. Excess cancer risk ($8E-6$) was also below the acceptable risk value provided by the NMED for an industrial land use scenario (Bearzi January 2001). In many locations, TPH, VOC and SVOC samples were collected concurrently. However, the maximum concentration of TPH in the interval from 0 to 5 feet had only an associated VOC sample. The maximum TPH concentration from 0 to total investigation depth had neither associated VOC nor SVOC sample results. The COCs for diesel #2 were determined (NMED March 2000) and concentrations of these COCs were conservatively derived from the maximum TPH concentration (Potter and Simmons 1998) (Appendix 1) for both the human health and ecological risk screening assessments. The conversion of TPH to diesel #2 COCs also was considered to be very conservative. Diesel #2 was introduced into the environment in 1991. Benzene, which is the main risk driver, most likely would be almost completely removed from the environment by now. However, the TPH to diesel #2 COCs conversion assumes that the contamination occurred recently and that the diesel #2 is fresh.

Uncertainties associated with the calculations are considered to be small relative to the conservativeness of risk assessment analysis. It is, therefore, concluded that this site poses no significant risk to human health under the industrial land use scenario.

VII. Ecological Risk Screening Assessment

VII.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPEC) in soils at SWMU 190. A component of the NMED Risk-Based Decision Tree (NMED March 1998) is to conduct an ecological screening assessment that corresponds with that presented in EPA's Ecological Risk Assessment Guidance for Superfund (EPA 1997c). The current methodology is tiered and contains an initial scoping assessment followed by a more detailed screening assessment. Initial components of NMED's decision tree (a discussion of DQOs, data assessment, and evaluations of both bioaccumulation and fate and transport potential) are addressed in previous sections of this report. Following the completion of the scoping assessment, a determination is made as to whether a more detailed examination of potential ecological risk is necessary. If deemed necessary, the scoping assessment proceeds to a screening assessment whereby a more quantitative estimate of ecological risk is conducted. Although this assessment incorporates conservatism in the estimation of ecological risks, ecological relevance and professional judgment also are used as recommended by the EPA (1998b) to ensure that predicted exposures of selected ecological receptors reflect those reasonably expected to occur at the site.

VII.2 Scoping Assessment

The scoping assessment focuses primarily on the likelihood of exposure of biota at or adjacent to the site to be exposed to constituents associated with site activities. Included in this section are an evaluation of existing data and a comparison of maximum detected concentrations to background concentrations, examination of bioaccumulation potential, and fate and transport potential. A scoping risk-management decision (Section VII.2.4) involves summarizing the scoping results and determining whether further examination of potential ecological impacts is necessary.

VII.2.1 Data Assessment

As indicated in Section IV (Table 3), organic analytes detected in soil were as follows:

- Acenaphthene
- Anthracene
- Benzene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene

- Chrysene
- Ethylbenzene
- Fluoranthene
- Fluorene
- Naphthalene
- Phenanthrene
- Pyrene
- Toluene
- Xylene, total.

Analyses of the soils from this site did not include inorganic constituents.

VII.2.2 Bioaccumulation

Among the COPECs listed in Section VII.2.1, the following were considered to have bioaccumulation potential in aquatic environments (Section IV, Table 3):

- Acenaphthene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Chrysene
- Fluoranthene
- Fluorene
- Naphthalene
- Phenanthrene
- Pyrene.

VII.2.3 Fate and Transport Potential

The potential for the COPECs to migrate from the source of contamination to other media or biota is discussed in Section V. As noted in Table 4 (Section V), wind and surface water may be of moderate significance as transport mechanisms for COPECs at this site. Migration to groundwater is not anticipated. Food chain uptake is expected to be of very low significance. Degradation and transformation of the organic COPECs may be of moderate significance as a mechanism of loss, and some of these COPECs may be lost through volatilization.

VII.2.4 Scoping Risk-Management Decision

Based upon information gathered through the scoping assessment, it was concluded that complete ecological pathways may be associated with this SWMU and that COPECs also exist

at the site. As a consequence, a screening assessment was deemed necessary to predict the potential level of ecological risk associated with the site.

VII.3 Screening Assessment

As concluded in Section VII.2.4, both complete ecological pathways and COPECs are associated with this SWMU. The screening assessment performed for the site involves a quantitative estimate of current ecological risks using exposure models in association with exposure parameters and toxicity information obtained from the literature. The estimation of potential ecological risks is conservative to ensure that ecological risks are not underpredicted.

Components within the screening assessment include the following:

- Problem Formulation—sets the stage for the evaluation of potential exposure and risk.
- Exposure Estimation—provides a quantitative estimate of potential exposure.
- Ecological Effects Evaluation—presents benchmarks used to gauge the toxicity of COPECs to specific receptors.
- Risk Characterization—characterizes the ecological risk associated with exposure of the receptors to environmental media at the site.
- Uncertainty Assessment—discusses uncertainties associated with the estimation of exposure and risk.
- Risk Interpretation—evaluates ecological risk in terms of HQs and ecological significance.
- Screening Assessment Scientific/Management Decision Point—presents the decision to risk managers based upon the results of the screening assessment.

VII.3.1 Problem Formulation

Problem formulation is the initial stage of the screening assessment that provides the introduction to the risk evaluation process. Components that are addressed in this section include a discussion of ecological pathways and the ecological setting, identification of COPECs, and selection of ecological receptors. The conceptual model, ecological food webs, and ecological endpoints (other components commonly addressed in a screening assessment) are presented in the "Predictive Ecological Risk Assessment Methodology for SNL/NM ER Program" (IT July 1998) and are not duplicated here.

VII.3.1.1 *Ecological Pathways and Setting*

SWMU 190 is approximately 3 acres in size. The site is located in an area originally dominated by grassland habitat, but this habitat has been highly disturbed and modified by the construction and use of the tank farm. The site is essentially devoid of vegetation. Although surrounded by a chain-link fence, the site is generally open to use by wildlife; however, very little use by wildlife is expected due to the lack of habitat. Because of the degree of disturbance, no threatened, endangered, or other sensitive species are expected to occur within this SWMU.

Complete ecological pathways may exist at this site through the exposure of plants and wildlife to COPECs in surface and near-surface soil at this site. It was assumed that direct uptake of COPECs from soil is the major route of exposure for plants and that exposure of plants to wind-blown soil is minor. Exposure modeling for the wildlife receptors was limited to the food and soil ingestion pathways. Because of the lack of surface water at this site, exposure to COPECs through the ingestion of surface water was considered insignificant. Inhalation and dermal contact were also considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Groundwater is not expected to be affected by COCs at this site.

VII.3.1.2 *COPECs*

A leak of diesel oil from a pipeline is the source of the COPECs associated with the soils at SWMU 190. Only organic COPECs have been identified for SWMU 190. These are listed in Section VII.2.1. All organic analytes detected were considered to be COPECs for the site. In order to provide conservatism, this ecological risk assessment was based upon the maximum soil concentrations of the COPECs measured in the surface soil at this site. Table 3 (Section IV) presents the maximum concentrations for the COPECs.

VII.3.1.3 *Ecological Receptors*

A nonspecific perennial plant was selected as the receptor to represent plant species at the site (IT July 1998). Vascular plants are the principal primary producers at the site and are key to the diversity and productivity of the wildlife community associated with the site. The deer mouse (*Peromyscus maniculatus*) and the burrowing owl (*Speotyto cunicularia*) were used to represent wildlife use. Because of its opportunistic food habits, the deer mouse was used to represent a mammalian herbivore, omnivore, and insectivore. The burrowing owl was selected to represent a top predator at this site. The burrowing owl is present at SNL/NM and is designated a species of management concern by the U.S. Fish and Wildlife Service in Region 2, which includes the state of New Mexico (USFWS September 1995).

VII.3.2 *Exposure Estimation*

For the COPECs at SWMU 190, direct uptake from the soil was considered the only significant route of exposure for terrestrial plants. Exposure modeling for the wildlife receptors was limited to food and soil ingestion pathways. Inhalation and dermal contact were considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Drinking water also was considered an insignificant pathway because of the lack of surface water at this site. The deer mouse was modeled under three dietary regimes: as an herbivore (100 percent of its diet

as plant material), as an omnivore (50 percent of its diet as plants and 50 percent as soil invertebrates), and as an insectivore (100 percent of its diet as soil invertebrates). The burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Because the exposure in the burrowing owl from a diet consisting of equal parts of herbivorous, omnivorous, and insectivorous mice would be equivalent to the exposure consisting of only omnivorous mice, the diet of the burrowing owl was modeled with intake of omnivorous mice only. Both species were modeled with soil ingestion comprising 2 percent of the total dietary intake. Table 7 presents the species-specific factors used in modeling exposures in the wildlife receptors. Justification for use of the factors presented in this table is described in the ecological risk assessment methodology document (IT July 1998).

Although home range also is included in this table, exposures for this risk assessment were modeled using an area use factor of 1, implying that all food items and soil ingested come from the site being investigated. The maximum measured TPH concentration was used to derive maximum COPEC concentrations in soil samples. These derived COPEC concentrations were used to conservatively estimate potential exposures and risks to plants and wildlife at this site.

Table 8 provides the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 9 presents maximum concentrations in soil and derived concentrations in tissues of the various food chain elements that are used to model dietary exposures for each of the wildlife receptors.

VII.3.3 Ecological Effects Evaluation

Table 10 shows benchmark toxicity values for the plant and wildlife receptors. For plants, the benchmark soil concentrations are based upon the lowest-observed-adverse-effect level (LOAEL). For wildlife, the toxicity benchmarks are based upon the no-observed-adverse-effect level (NOAEL) for chronic oral exposure in a taxonomically similar test species. Sufficient toxicity information was not available to estimate the LOAELs for plants for benzene, ethylbenzene, and xylenes, and NOAELs for the burrowing owl for all COPECs.

VII.3.4 Risk Characterization

Maximum concentrations in soil and estimated dietary exposures were compared to plant and wildlife benchmark values, respectively. Table 11 presents the results of these comparisons. HQs are used to quantify the comparison with benchmarks for plant and wildlife exposure.

HQs for plants exceeded unity for acenaphthene, fluorene, naphthalene, and phenanthrene. HQs exceeded unity for all three dietary regimes in the deer mouse for acenaphthene, naphthalene, and xylenes. HQs exceeded unity for the omnivorous and insectivorous deer mice for fluorene, phenanthrene, and toluene. In addition, the HQ for the insectivorous deer mouse exceeded unity for benzene. HQs for plants for benzene, ethylbenzene, and xylenes could not be determined because of a lack of sufficient toxicity information, and no HQs for the burrowing owl could be determined for the same reason. As directed by the NMED, HIs were calculated for each of the receptors (the HI is the sum of chemical-specific HQs for all pathways for a given receptor). All receptors (except the burrowing owl) had total HIs greater than unity, with a maximum HI of 1,300 for the insectivorous deer mouse.

Table 7
Exposure Factors for Ecological Receptors at SWMU 190

Receptor Species	Class/Order	Trophic Level	Body Weight (kg) ^a	Food Intake Rate (kg/day) ^b	Dietary Composition ^c	Home Range (acres)
Deer Mouse (<i>Peromyscus maniculatus</i>)	Mammalia/ Rodentia	Herbivore	2.39E-2 ^d	3.72E-3	Plants: 100% (+ Soil at 2% of intake)	2.7E-1 ^e
Deer Mouse (<i>Peromyscus maniculatus</i>)	Mammalia/ Rodentia	Omnivore	2.39E-2 ^d	3.72E-3	Plants: 50% Invertebrates: 50% (+ Soil at 2% of intake)	2.7E-1 ^e
Deer Mouse (<i>Peromyscus maniculatus</i>)	Mammalia/ Rodentia	Insectivore	2.39E-2 ^d	3.72E-3	Invertebrates: 100% (+ Soil at 2% of intake)	2.7E-1 ^e
Burrowing owl (<i>Speotyto cunicularia</i>)	Aves/ Strigiformes	Carnivore	1.55E-1 ^f	1.73E-2	Rodents: 100% (+ Soil at 2% of intake)	3.5E+1 ^g

^aBody weights are in kg wet weight.

^bFood intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kg dry weight per day.

^cDietary compositions are generalized for modeling purposes. Default soil intake value of 2% of food intake.

^dFrom Silva and Downing (1995).

^eEPA (1993), based upon the average home range measured in semiarid shrubland in Idaho.

^fFrom Dunning (1993).

^gFrom Haug et al. (1993).

EPA = U.S. Environmental Protection Agency.

kg = Kilogram(s).

kg/day = Kilogram(s) per day.

SWMU = Solid Waste Management Unit.

Table 8
Transfer Factors Used in Exposure Models for
Constituents of Potential Ecological Concern at SWMU 190

Constituent of Potential Ecological Concern	Soil-to-Plant Transfer Factor	Soil-to-Invertebrate Transfer Factor	Food-to-Muscle Transfer Factor
Organic^a			
Acenaphthene	2.1E-1	2.1E+1	2.1E-4
Anthracene	1.0E-1	2.2E+1	7.3E-4
Benzene	2.3E+0	1.7E+1	2.9E-6
Benzo(a)anthracene	2.2E-2	2.5E+1	1.1E-2
Benzo(a)pyrene	1.1E-2	2.7E+1	3.8E-2
Benzo(b)fluoranthene	6.2E-3	2.8E+1	1.1E-1
Benzo(k)fluoranthene	4.3E-3	2.9E+1	2.1E-1
Chrysene	1.5E-2	2.6E+1	2.3E-2
Ethylbenzene	5.9E-1	1.9E+1	3.3E-5
Fluoranthene	5.7E-2	2.3E+1	2.1E-3
Fluorene	1.5E-1	2.1E+1	3.8E-4
Naphthalene	4.8E-1	1.9E+1	4.7E-5
Phenanthrene	8.9E-2	2.2E+1	9.6E-4
Pyrene	3.3E-2	2.4E+1	5.8E-3
Toluene	1.0E+0	1.8E+1	1.3E-5
Xylenes	5.5E-1	1.9E+1	3.7E-5

^aSoil-to-plant and food-to-muscle transfer factors from equations developed in Travis and Arms (1988). Soil-to-invertebrate transfer factors from equations developed in Connell and Markwell (1990). All three equations are based upon the relationship of the transfer factor to the log K_{ow} value of compound.

K_{ow} = Octanol-water partition coefficient.

log = Logarithm (base 10).

SWMU = Solid Waste Management Unit.

Table 9
Media Concentrations^a for Constituents of
Potential Ecological Concern at SWMU 190

Constituent of Potential Ecological Concern	Soil (maximum) ^a	Plant Foliage ^b	Soil Invertebrate ^b	Deer Mouse Tissues ^c
Organic				
Acenaphthene	7.4E+2	1.6E+2	1.5E+4	5.0E+0
Anthracene	2.3E+0	2.4E-1	5.0E+1	5.8E-2
Benzene	1.1E+1	2.6E+1	1.9E+2	9.9E-4
Benzo(a)anthracene	3.7E-2	8.2E-4	9.3E-1	1.7E-2
Benzo(a)pyrene	8.6E-2	9.8E-4	2.3E+0	1.3E-1
Benzo(b)fluoranthene	1.2E-2	7.4E-5	3.4E-1	5.9E-2
Benzo(k)fluoranthene	1.2E-2	5.2E-5	3.5E-1	1.2E-1
Chrysene	1.8E-2	2.7E-4	4.7E-1	1.7E-2
Ethylbenzene	2.7E+1	1.6E+1	5.0E+2	2.7E-2
Fluoranthene	2.3E+0	1.3E-1	5.3E+1	1.8E-1
Fluorene	2.2E+2	3.2E+1	4.6E+3	2.8E+0
Naphthalene	1.2E+3	5.8E+2	2.3E+4	1.8E+0
Phenanthrene	3.4E+1	3.0E+0	7.6E+2	1.2E+0
Pyrene	1.8E+0	5.9E-2	4.4E+1	3.9E-1
Toluene	7.0E+1	7.0E+1	1.3E+3	2.7E-2
Xylenes	2.0E+2	1.1E+2	3.7E+3	2.2E-1

^aIn milligrams per kilogram. All biotic media are based upon dry weight of the media. Soil concentration measurements are assumed to have been based upon dry weight. Values have been rounded to two significant digits after calculation.

^bProduct of the soil concentration and the corresponding transfer factor.

^cBased upon the deer mouse with an omnivorous diet. Product of the average concentration ingested in food and soil times the food-to-muscle transfer factor times a wet weight-dry weight conversion factor of 3.125 (EPA 1993).

EPA = U.S. Environmental Protection Agency.

SWMU = Solid Waste Management Unit.

Table 10
Toxicity Benchmarks for Ecological Receptors at SWMU 190

Constituent of Potential Ecological Concern	Plant Benchmark ^{a,b}	Mammalian NOAELs			Avian NOAELs		
		Mammalian Test Species ^{c,d}	Test Species NOAEL ^{d,e}	Deer Mouse NOAEL ^{e,f}	Avian Test Species ^d	Test Species NOAEL ^{d,e}	Burrowing Owl NOAEL ^{e,g}
Organic							
Acenaphthene	18	mouse	17.5 ^h	18.5	—	—	—
Anthracene	18	mouse	100 ⁱ	106	—	—	—
Benzene	—	mouse	26.4	27.9	—	—	—
Benzo(a)anthracene	18	mouse	1.0 ^j	1.06	—	—	—
Benzo(a)pyrene	18	mouse	1.0 ^j	1.06	—	—	—
Benzo(b)fluoranthene	18	mouse	1.0 ^j	1.06	—	—	—
Benzo(k)fluoranthene	18	mouse	1.0 ^j	1.06	—	—	—
Chrysene	18	mouse	1.0 ^j	1.06	—	—	—
Ethylbenzene	—	rat	291 ^h	569	—	—	—
Fluoranthene	18	mouse	12.5 ^k	13.23	—	—	—
Fluorene	18	mouse	12.5 ^j	13.23	—	—	—
Naphthalene	18	mouse	5.0 ^m	5.29	—	—	—
Phenanthrene	18	mouse	1.0 ^j	1.06	—	—	—
Pyrene	18	mouse	7.5 ⁿ	7.94	—	—	—
Toluene	200 ^o	mouse	26	27.5	—	—	—
Xylenes	—	mouse	2.1	2.22	—	—	—

^aIn milligrams per kilogram soil dry weight.

^bFrom Sims and Overcash (1983), except where noted.

^cBody weights (in kilograms) for the NOAEL conversion are as follows: lab mouse, 0.030; lab rat, 0.350 (except where noted).

^dFrom Sample et al. (1996), except where noted.

^eIn milligrams per kilogram body weight per day.

^fBased upon NOAEL conversion methodology presented in Sample et al. (1996), using a deer mouse body weight of 0.0239 kilogram and a mammalian scaling factor of 0.25.

^gBased upon NOAEL conversion methodology presented in Sample et al. (1996). The avian scaling factor of 0.0 was used, making the NOAEL independent of body weight.

^hBased upon EPA (1998a).

ⁱNOAEL based upon the highest dose (1,000 mg/kg/d, subchronic) (EPA 1989b) and an uncertainty factor of 0.1.

^jInsufficient toxicity data available for this compound. The NOAEL for benzo(a)pyrene is used as default.

Table 10 (Concluded)
Toxicity Benchmarks for Ecological Receptors at SWMU 190

- ^kBased upon subchronic NOAEL of 125 mg/kg/d (EPA 1988) and an uncertainty factor of 0.1.
^lBased upon subchronic NOAEL of 125 mg/kg/d (EPA 1989c) and an uncertainty factor of 0.1.
^mTest species NOAEL based upon mouse NOAEL for pyrene (7.5 mg/kg/d) and ratio of LD₅₀ values (533/800) from RTECS (1997).
ⁿBased upon subchronic NOAEL of 75 mg/kg/d (EPA 1989d) and an uncertainty factor of 0.1.
^oBenchmark based upon LOAELs (lowest concentration tested) (Overcash et al. 1982).
- EPA = U.S. Environmental Protection Agency.
LD₅₀ = Acute lethal dose to 50 percent of the test population.
LOAEL = Lowest-observed-adverse-effect-level.
mg/kg/d = Milligrams per kilogram per day.
NOAEL = No-observed-adverse-effect-level.
RTECS = Registry of Toxic Effects of Chemical Substances.
SWMU = Solid Waste Management Unit.
– = Insufficient toxicity data.

Table 11
Hazard Quotients for Ecological Receptors at SWMU 190

Constituent of Potential Ecological Concern	Plant HQ ^a	Deer Mouse HQ (Herbivorous) ^a	Deer Mouse HQ (Omnivorous) ^a	Deer Mouse HQ (Insectivorous) ^a	Burrowing Owl HQ ^a
Organic					
Acenaphthene	4.1E+1	1.4E+0	6.5E+1	1.3E+2	—
Anthracene	1.3E-1	4.2E-4	3.7E-2	7.4E-2	—
Benzene	—	1.4E-1	6.0E-1	1.1E+0	—
Benzo(a)anthracene	2.1E-3	2.3E-4	6.8E-2	1.4E-1	—
Benzo(a)pyrene	4.8E-3	4.0E-4	1.7E-1	3.4E-1	—
Benzo(b)fluoranthene	6.7E-4	4.6E-5	2.5E-2	4.9E-2	—
Benzo(k)fluoranthene	6.7E-4	4.3E-5	2.6E-2	5.1E-2	—
Chrysene	1.0E-3	9.2E-5	3.4E-2	6.9E-2	—
Ethylbenzene	—	4.4E-3	7.1E-2	1.4E-1	—
Fluoranthene	1.3E-1	2.1E-3	3.1E-1	6.3E-1	—
Fluorene	1.2E+1	4.3E-1	2.8E+1	5.5E+1	—
Naphthalene	6.7E+1	1.8E+1	3.5E+2	6.8E+2	—
Phenanthrene	1.9E+0	5.5E-1	5.6E+1	1.1E+2	—
Pyrene	1.0E-1	1.9E-3	4.3E-1	8.6E-1	—
Toluene	3.5E-1	4.0E-1	3.8E+0	7.2E+0	—
Xylenes	—	7.7E+0	1.3E+2	2.6E+2	—
HI ^b	1.2E+2	2.9E+1	6.4E+2	1.3E+3	—

^a**Bold** values indicate the HQ or HI exceeds unity.

^bThe HI is the sum of individual HQs.

HI = Hazard index.

HQ = Hazard quotient.

SWMU = Solid Waste Management Unit.

— = Insufficient toxicity data available for risk estimation purposes.

VII.3.5 Uncertainty Assessment

Many uncertainties are associated with the characterization of ecological risks at SWMU 190. These uncertainties result from assumptions used in calculating risk that could overestimate or underestimate true risk presented at a site. For this risk assessment, assumptions are made that are more likely to overestimate exposures and risk rather than to underestimate them. These conservative assumptions are used to be more protective of the ecological resources potentially affected by the site. Conservatisms incorporated into this risk assessment include the use of maximum analyte concentrations measured in soil samples to evaluate risk, the use of wildlife toxicity benchmarks based upon NOAEL values, and the incorporation of strict herbivorous and strict insectivorous diets for predicting the extreme HQ values for the deer mouse. Each of these uncertainties, which are consistent among each of the SWMU-specific ecological risk assessments, is discussed in greater detail in the uncertainty section of the ecological risk assessment methodology document for the SNL/NM ER Project (IT July 1998).

A significant source of uncertainty associated with the prediction of ecological risk at this site is the use of the maximum measured TPH concentration as the basis for estimating the individual COPEC concentrations used to evaluate exposure and risk. To assess the potential degree of overestimation caused by using this maximum value, HQs were recalculated for those COPECs with HQs greater than unity using COPEC concentrations estimated from the mean TPH concentration. As with the COPEC concentrations estimated from the maximum TPH concentration, the concentrations estimated from the mean were based upon the fractions of the component chemicals in diesel #2. The mean TPH concentration was based upon 55 TPH measurements collected in the upper 5 feet of soil at the site and incorporated nondetections as one half the detection limit. It should be noted that of the 55 samples included in the calculation of the mean TPH concentration, only two were above the detection limit of 50 milligrams (mg)/kilogram (kg). Therefore, the frequency of detection for TPH in samples between 0 and 5 feet in depth at this site was approximately 3.6 percent.

The estimated mean concentrations of acenaphthene, benzene, and toluene (17.9, 0.273, and 1.70 mg/kg, respectively) resulted in no HQs greater than unity; however, the estimated mean concentrations of fluorene, naphthalene, phenanthrene, and xylenes (5.28, 29.2, 0.829, and 47.1 mg/kg, respectively) all resulted in one or more HQs exceeding unity, with a maximum HQ of 17 for the insectivorous deer mouse exposure to naphthalene. Therefore, the use of the maximum TPH values does account for the initial prediction of potential ecological risk for three of the seven COPECs (acenaphthene, benzene, and toluene), with the remaining predictions of potential risk (for fluorene, naphthalene, phenanthrene, and xylenes) being relatively low.

The exposure estimations used in this assessment assume that ecological receptors occur on the site and that the habitat of the site is capable of supporting the use of these receptors. As described in Sections I and VII.3.1.1, the site is essentially devoid of vegetation, the habitat of the site has been highly disturbed and modified by its use as a tank farm, and its future use will continue to be industrial. Therefore, the potential for current and future exposures of ecological receptors to COPECs at this site is low. Additionally, the very low frequency of detection of TPH in the near-surface soils indicates that the COPECs are highly restricted in areal extent, further reducing the potential for significant ecological exposure. Because of the lack of habitat and the highly restricted extent of contamination in the near-surface soil at this site, the potential for significant ecological risk is low.

Based upon this uncertainty analysis, ecological risks at SWMU 190 are expected to be generally low. HQs greater than unity were initially predicted; however, these values were found to be highly conservative overestimations of potential risk, primarily attributable to the conservative nature of the assumed exposure concentrations. Further, due to the highly restricted extent of contaminants on the site, the lack of sufficient habitat to attract or support ecological receptors, and the fact that the site will continue to be used as an industrial site, significant exposure of ecological receptors to COPECs at this site is unlikely to occur.

VII.3.6 Risk Interpretation

Ecological risks associated with SWMU 190 were estimated through a screening assessment that incorporated site-specific information when available. Overall, risks to ecological receptors are expected to be low because predicted risks associated with exposure to COPECs are based upon calculations using the maximum measured TPH concentration. These concentrations, when based upon the mean TPH concentration, resulted in HQs less than unity for three of the seven COPECs initially showing potential risk (acenaphthene, benzene, and toluene), and relatively low HQs (less than or equal to 17) for the remaining COPECs (fluorene, naphthalene, phenanthrene, and xylenes). It is likely, however, that these remaining predictions of risk are greatly overestimated considering that the COPECs are highly restricted in areal extent on the site, the site lacks sufficient habitat to attract or support ecological receptors, and the site will continue to be used as an industrial site. Based upon this final analysis, ecological risks associated with SWMU 190 are expected to be low.

VII.3.7 Screening Assessment Scientific/Management Decision Point

After potential ecological risks associated with the site have been assessed, a decision is made regarding whether the site should be recommended for NFA or whether additional data should be collected to assess actual ecological risk at the site more thoroughly. With respect to this site, ecological risks are predicted to be low. The scientific/management decision is to recommend this site for NFA.

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APPENDIX 1

CONVERSION OF TPH TO DIESEL #2 CONSTITUENTS OF CONCERN

A documented release of fuel oil at Solid Waste Management Unit (SWMU) 190 occurred in June 1991. To characterize the site, samples for total petroleum hydrocarbons (TPH), volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs) were collected. The maximum concentration of TPH in the interval from 0 to 5 feet had only an associated VOC sample. The maximum TPH concentration from 0 to total investigation depth did not have either an associated VOC or SVOC sample result. Therefore, the constituents of concern (COCs) for diesel #2 were determined (NMED March 2000) and concentrations of these COCs were derived from the maximum TPH concentration (0 to total depth) (Potter and Simmons 1998) for both the human health and ecological risk screening assessments. This appendix describes this process.

The New Mexico Underground Storage Tank Bureau, in "Guidelines for Corrective Action" (NMED March 2000), lists the contaminants of concern for different product releases including diesel and light fuel oils (Table 1). The average weight percent in TPH of each COC was then identified from Potter and Simmons (1998). A calculation was then performed to determine the maximum chemical concentration of each COC from its weight percent and the maximum TPH concentration (Table 2).

Table 1
Contaminants of Concern for Diesel and Light Fuel Oils (NMED March 2000)

Contaminant	Cancer Class ^a
Benzene	Human carcinogen
Toluene	Noncarcinogen
Ethylbenzene	Noncarcinogen
Xylenes (total)	Noncarcinogen
Acenaphthene	Noncarcinogen
Anthracene	Noncarcinogen
Benz(a)anthracene	Probable human carcinogen
Benzo(a)pyrene	Probable human carcinogen
Benzo(b)fluoranthene	Probable human carcinogen
Benzo(k)fluoranthene	Probable human carcinogen
Chrysene	Probable human carcinogen
Dibenz(a,h)anthracene	Probable human carcinogen
Fluoranthene	Noncarcinogen
Fluorene	Noncarcinogen
Total Naphthalenes	Noncarcinogen
Phenanthrene	Noncarcinogen
Pyrene	Noncarcinogen
Total Petroleum Hydrocarbons	Noncarcinogen

^aHuman carcinogen = Group A under EPA weight of evidence classification system for carcinogenicity.
 Probable human carcinogen = Group B1 or B2 under EPA weight of evidence classification system for carcinogenicity.

EPA = U.S. Environmental Protection Agency.

NMED = New Mexico Environment Department.

Table 2
Conversion of TPH to Diesel #2 COCs

Chemical Name	Average Weight %	Maximum TPH Concentration (mg/kg)	Maximum Chemical Concentration (mg/kg)
Benzene	2.9E-2	39000	11.3
Toluene	1.8E-1	39000	70.2
Ethylbenzene	6.8E-2	39000	26.5
Xylenes (total)	5.0E-1	39000	195
Acenaphthene	1.9E+0	39000	741
Anthracene	5.8E-3	39000	2.3
Benzo(a)anthracene	9.6E-5	39000	0.037
Benzo(a)pyrene	2.2E-4	39000	0.086
Benzo(b)fluoranthene ^a	3.1E-5	39000	0.012
Benzo(k)fluoranthene ^a	3.1E-5	39000	0.012
Chrysene	4.5E-5	39000	0.018
Dibenz(a,h)anthracene ^b	0	39000	0
Fluoranthene	5.9E-3	39000	2.3
Fluorene ^c	5.6E-1	39000	218
Total Naphthalenes ^d	3.1E+0	39000	1209
Phenanthrene	8.8E-2	39000	34.3
Pyrene	4.6E-3	39000	1.8

^aBenzo(b+k)fluoranthene listed as 3.1E-5 weight %. Conservatively used maximum chemical concentration derived from combined weight % for individual COCs.

^bDibenz(a,h)anthracene not listed as a component of Diesel #2 in Potter and Simmons (1998).

^cUsed average weight % of total fluorenes.

^dRisk calculated from concentration being solely naphthalene due to lack of toxicological parameter values for other naphthalenes.

COC = Constituent of concern.

mg/kg = Milligram(s) per kilogram.

TPH = Total petroleum hydrocarbons.

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APPENDIX 2 EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

Introduction

Sandia National Laboratories/New Mexico (SNL/NM) proposes that a default set of exposure routes and associated default parameter values be developed for each future land use designation being considered for SNL/NM Environmental Restoration (ER) project sites. This default set of exposure scenarios and parameter values would be invoked for risk assessments unless site-specific information suggested other parameter values. Because many SNL/NM solid waste management units (SWMU) have similar types of contamination and physical settings, SNL/NM believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values will facilitate the risk assessments and subsequent review.

The default exposure routes and parameter values suggested are those that SNL/NM views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the U.S. Environmental Protection Agency (EPA) Region VI and New Mexico Environment Department (NMED), SNL/NM proposes that these default exposure routes and parameter values be used in future risk assessments.

At SNL/NM, all SWMUs exist within the boundaries of the Kirtland Air Force Base (KAFB). Approximately 157 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/NM ER draft Environmental Assessment (DOE 1996) presents a summary of the hydrogeology of the sites, the biological resources present and proposed land use scenarios for the SNL/NM SWMUs. At this time, all SNL/NM SWMUs have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based upon a residential land-use scenario. All three land use scenarios will be addressed in this document.

The SNL/NM ER project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent Hazard index (HI), excess cancer risk and dose values. The EPA (EPA 1989a) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water
- Ingestion of contaminated soil
- Ingestion of contaminated fish and shellfish
- Ingestion of contaminated fruits and vegetables

- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming
- Dermal contact with chemicals in water
- Dermal contact with chemicals in soil
- Inhalation of airborne compounds (vapor phase or particulate)
- External exposure to penetrating radiation (immersion in contaminated air, immersion in contaminated water, and exposure from ground surfaces with photon-emitting radionuclides).

Based upon the location of the SNL/NM SWMUs and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM SWMUs, currently no consumption of fish, shellfish, fruits, vegetables, meat, eggs, or dairy occurs for products that originate on site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land use scenarios, SNL/NM ER has, therefore, excluded the following four potential exposure routes from further risk assessment evaluations at any SNL/NM SWMU:

- Ingestion of contaminated fish and shellfish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming.

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water also is eliminated.

For the residential land use scenario, we will include ingestion of contaminated fruits and vegetables because of the potential for residential gardening.

Based upon this evaluation, for future risk assessments the exposure routes that will be considered are shown in Table 1. Dermal contact is included as a potential exposure pathway in all land use scenarios. However, the potential for dermal exposure to inorganic compounds is not considered significant and will not be included. In general, the dermal exposure pathway is generally not considered to be significant relative to water ingestion and soil ingestion pathways, but will be considered for organic components. Because of the lack of toxicological parameter values for this pathway, the inclusion of this exposure pathway into risk assessment calculations may not be possible and may be part of the uncertainty analysis for a site where dermal contact is potentially applicable.

Table 1
Exposure Pathways Considered for Various Land Use Scenarios

Industrial	Recreational	Residential
Ingestion of contaminated drinking water	Ingestion of contaminated drinking water	Ingestion of contaminated drinking water
Ingestion of contaminated soil	Ingestion of contaminated soil	Ingestion of contaminated soil
Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)
Dermal contact	Dermal contact	Dermal contact
External exposure to penetrating radiation from ground surfaces	External exposure to penetrating radiation from ground surfaces	Ingestion of fruits and vegetables
		External exposure to penetrating radiation from ground surfaces

Equations and Default Parameter Values for Identified Exposure Routes

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation also may be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land use scenarios. The general equations for calculating potential intakes via these routes are shown below. The equations are from the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA 1989a, 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). Also shown are the default values SNL/NM ER suggests for use in RME risk assessment calculations for industrial, recreational, and residential scenarios, based upon EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL 1993).

Generic Equation for Calculation of Risk Parameter Values

The equation used to calculate the risk parameter values (i.e., hazard quotients/hazard index [HI], excess cancer risk, or radiation total effective dose equivalent [dose]) is similar for all exposure pathways and is given by:

$$\begin{aligned} \text{Risk (or Dose)} &= \text{Intake} \times \text{Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)} \\ &= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \end{aligned} \quad (1)$$

where

C = contaminant concentration (site specific)
CR = contact rate for the exposure pathway
EFD = exposure frequency and duration
BW = body weight of average exposure individual
AT = time over which exposure is averaged.

The total risk/dose (either cancer risk or HI) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants.

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the constituents of concern (COC) present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk range of $1E-6$ for Class A and B carcinogens and $1E-5$ for Class C carcinogens. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the HI) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard HI of unity (1). The evaluation of the health hazard due to radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA 1989a) and the RESRAD Manual (ANL 1993). Table 2 shows the default parameter values suggested for use by SNL/NM at SWMUs, based upon the selected land use scenario. References are given at the end of the table indicating the source for the chosen parameter values. The intention of SNL/NM is to use default values that are consistent with regulatory guidance and consistent with the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are suggested for use for the various exposure pathways based upon the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL/NM proposes the described default exposure routes and parameter values for use in risk assessments at sites that have an industrial, recreational or residential future land use scenario. There are no current residential land use designations at SNL/NM ER sites, but this scenario has been requested to be considered by the NMED. For sites designated as industrial or recreational land use, SNL/NM will provide risk parameter values based upon a residential land use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on SNL/NM ER sites. The parameter values are based upon EPA guidance and supplemented by information from other government sources. The values are generally consistent with those proposed by Los Alamos National Laboratory, with a few minor variations. If these exposure routes and parameters are acceptable, SNL/NM will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

Table 2
Default Parameter Values for Various Land Use Scenarios

Parameter	Industrial	Recreational	Residential
General Exposure Parameters			
Exposure frequency	8 hr/day for 250 day	4 hr/wk for 52 wk/yr	350 day/yr
Exposure duration (yr)	25 ^{a,b}	30 ^{a,b}	30 ^{a,b}
Body weight (kg)	70 ^{a,b}	70 adult ^{a,b} 15 child	70 adult ^{a,b} 15 child
Averaging Time (days) for carcinogenic compounds (= 70 y x 365 day/yr)	25,550 ^a	25,550 ^a	25,550 ^a
for noncarcinogenic compounds (= ED x 365 day/yr)	9,125	10,950	10,950
Soil Ingestion Pathway			
Ingestion rate	100 mg/day ^c	200 mg/day child 100 mg/day adult	200 mg/day child 100 mg/day adult
Inhalation Pathway			
Inhalation rate (m ³ /yr)	5,000 ^{a,b}	260 ^d	7,000 ^{a,b,d}
Volatilization factor (m ³ /kg)	Chemical specific	chemical specific	chemical specific
Particulate emission factor (m ³ /kg)	1.32E9 ^a	1.32E9 ^a	1.32E9 ^a
Water Ingestion Pathway			
Ingestion rate (liter/day)	2 ^{a,b}	2 ^{a,b}	2 ^{a,b}
Food Ingestion Pathway			
Ingestion rate (kg/yr)	NA	NA	138 ^{b,d}
Fraction ingested	NA	NA	0.25 ^{b,d}
Dermal Pathway			
Surface area in water (m ²)	2 ^{b,e}	2 ^{b,e}	2 ^{b,e}
Surface area in soil (m ²)	0.53 ^{b,e}	0.53 ^{b,e}	0.53 ^{b,e}
Permeability coefficient	Chemical specific	chemical specific	chemical specific

^aRisk Assessment Guidance for Superfund, Vol. 1, Part B (EPA 1991).

^bExposure Factors Handbook (EPA 1989b).

^cEPA Region VI guidance.

^dFor radionuclides, RESRAD (Argonne National Laboratory, 1993. *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD*, Version 5.0, ANL/EAD/LD-2, Argonne National Laboratory, Argonne, IL. 1993) is used for human health risk calculations; default parameters are consistent with RESRAD guidance.

^eDermal Exposure Assessment (EPA 1992).

ED = Exposure duration.

EPA = U.S. Environmental Protection Agency.

hr = Hour.

kg = Kilogram(s).

m² = Square meter(s).

m³ = Cubic meter(s).

mg = Milligram(s).

NA = Not available.

wk = Week.

yr = Year.

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October 13, 2003

ADDITIONAL /SUPPORTING DATA

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